A MANUAL OF EXPERIMENTS IN ELEMENTARY SCIENCE

CURTIS

STUDENT'S EDITION

CHARLES E. MERRILL COMPANY

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A MANUAL OF EXPERIMENTS

IN

ELEMENTARY SCIENCE

STUDENT'S EDITION

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BY

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EXPLANATION TO TEACHERS

This Manual of Experiments in Elementary Science consists of a Student's Manual comprising guide outlines, and a Teacher's Manual containing explanations, directions, and diagrams.

The outlines are adapted for use with classes in the upper grammar grades, the junior high school, and the first and second years of the high school.

The Manual can be used with any text dealing with beginning science, whether general science, physiography, agriculture, nature study, or physiology; or it can be made the basis of reference or syllabus courses without text, in any of the above subjects. It also correlates with courses in domestic science.

In schools where two or more elementary or second-year courses are offered, the Manual may be used by the same students two successive years.

The Manual can be used in accordance with the demonstration plan, the individual plan, or the partnership or group plan of laboratory course.

The book contains a large number of outlines from which the teacher can select; there are one hundred forty-six outlined experiments besides occasional alternates and suggested experiments.

The outlines in this Manual follow what is coming to be recognized as the logical method of presenting any experiment in science: Purpose or Object, Materials or Apparatus, Method or Observation, Conclusions or Deductions, Discussion, and Diagram.

Additional information concerning this Manual is contained in the Preface and Introduction to the Teacher's Manual.

Francis D. Curtis

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INTRODUCTION

SCIENCE is concerned with the search for TRUTH, which includes every *fact,* no matter what it is. *Every* invention which has ever been made was based upon some carefully applied principle of Science.

The primary purpose of this course in science is to make you think, question, investigate, and deduce correct conclusions from the results of your investigations. But of almost equal importance is the acquiring of ability to tell briefly but completely, accurately and in good English, all that was done, observed, and deduced.

Only the best and most careful work one is capable of is worth while. If a *formal* write-up is required, therefore, your reports should be written neatly in ink, in your best penmanship, and should be correct in spelling, punctuation, and all other details. The Model Experiment on page xx will show you a formal report exactly as it was submitted in a science course similar to the one you are taking.

The first thing to write in your report is the name of the course (physiography, general science, or whatever it may be) in the middle of the top line of the sheet. Write your name at the left-hand side of the next line, and the date on which the experiment is performed at the right-hand side of the same line. In the middle of the next line write the number of the experiment.

The PURPOSE may be copied exactly as it is stated at the beginning of each experiment.

After MATERIALS, write the names of all the different things which were used in performing the experiment.

Under METHOD, write a complete report of the entire experiment from beginning to end, telling all that was done, and all that happened. Do not leave anything out; your report should be so complete that anybody who reads it may know all about the ex-

periment without ever having seen it performed. Use the indicative mode, past tense; do not use *I* or *it* as the subject of any sentence, but use instead the name of some material or apparatus. Thus, "The flask was filled with water" instead of "I filled the flask with water," or "The teacher filled the flask with water," or "Fill the flask with water." Do not state any deductions or conclusions in your METHOD; they should be stated separately under the next heading.

Under CONCLUSIONS, tell what you infer to be true from the observation of the experiment. Make *complete statements* in answer to the questions; the questions will help you to formulate well-worded conclusions.

The DISCUSSION contains a very few of the innumerable questions which have a bearing upon the experiment. Your teacher will probably require you to look up these questions in various textbooks, and in thus learning how to find the information you need, you will be gaining valuable training and ability which will prove serviceable to you in *every* other study or work you may ever take up. Answer the questions under DISCUSSION with sentences so complete that anybody who reads them may know at once what were the questions you have answered.

If possible, draw your DIAGRAM of the apparatus upon a sheet of graph paper placed opposite the beginning of your report. Make a simple outline to represent as closely as you can just how the apparatus looked from the side, when the experiment was performed. Neat pencil diagrams are acceptable, but do not draw free-hand any lines which you could draw with a ruler. Write in their proper places all the *labels* suggested in your experiment outline, and beneath each diagram write a brief statement telling exactly what it is intended to represent.

Keep in mind that no work is really good which is not in every sense the *best* you can do. Do your notebook work so well that both you and your teacher can be proud of every page of it.

General Science

John Smith October 11, 1918

Experiment 3

Purpose: To measure the inside dimensions of a box in order to determine its capacity in cubic inches.

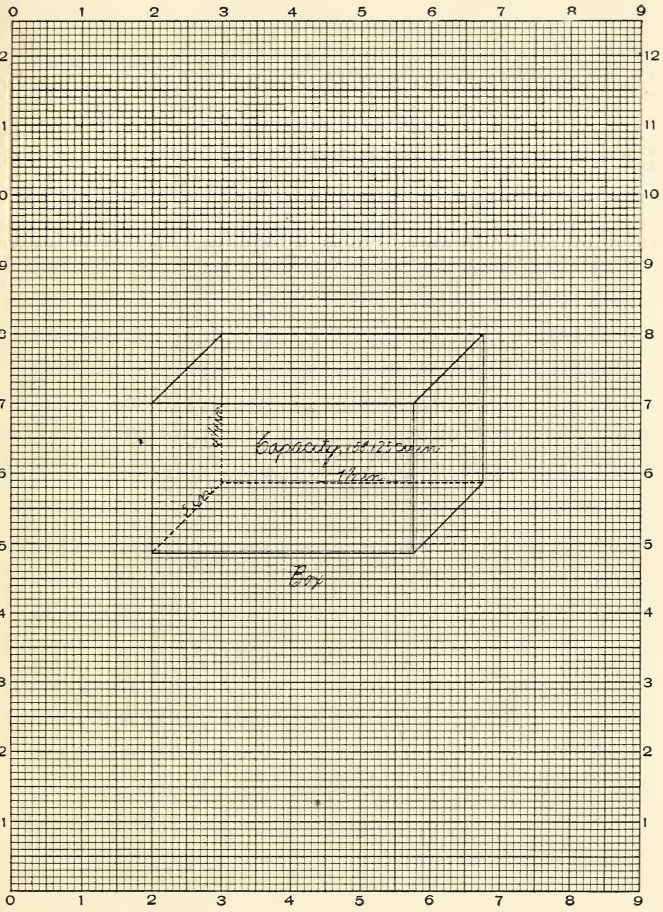
Materials: Box; small ruler.

Method: The inside dimensions of the box were carefully measured and found to be: length, 7½ in., width 5 in., depth 4⅛ in. The capacity of the box was then found by multiplying these three dimensions together.

Conclusion: The capacity of the box is $158.\frac{1}{8} = 158.125$ cu. in.

Discussion: 1. There are 231 cu. in., in one gallon. The capacity of the box would therefore be .68+ gal. 2. If the box were a tank full of water, and if 1 cu. ft. of water weighs 62.4 lb. the weight of water in the tank would be 5.7+ lb.

MODEL EXPERIMENT: Diagram



EXPERIMENTS IN ELEMENTARY SCIENCE

No. 1. EXPERIMENT ——

Purpose. — To study latitude in order to learn how to locate a place on the earth in terms of its latitude, and to determine the latitude of various points on the earth.

Materials.[1]

Method, Conclusions, and Discussion. — **1.** What line is determined by the fastest moving point on the rotating earth? **2.** A complete circle is 360°. What part of a circle is there between the slowest and the fastest moving points on the earth; and, therefore, how many degrees are there between these two points? **3.** If your pencil were held upon the rotating globe making a line parallel to the equator, what sort of figure would be drawn on the rotating globe by the pencil? **4.** How many such figures would it be possible to draw on the globe? **5.** What name is given corresponding figures mapped off on the earth? **6.** What is meant by the statement that two cities have the same latitude? **7.** What is the approximate latitude of Portland, Oregon? Of Lyons, France? Of your own home? Of Cape Horn? (Do not forget to state whether north or south latitude, *i.e.* north or south of the equator, as 6° N., 14° S.) **8.** What circle cuts through the middle of Formosa? Through south-

[1] The list of materials or apparatus is to be supplied by the teacher after he has made his selection.

ern Madagascar? **9.** What is the exact latitude of the equator? Of the tropics of Cancer and Capricorn? Of the arctic and antarctic circles? Of the north and south poles? **10.** How many degrees of latitude, approximately, are there between the parallel of Cairo, Egypt, and that of Rio de Janeiro? Between the south pole and Cape St. Lucas, Lower California? Between the parallel of Maskat, Arabia, and the mouth of the Amazon River?

No. 2. EXPERIMENT ——

Purpose. — To study longitude in order to learn how to locate a place on the earth in terms of its longitude, and to determine the longitude of various places on the earth.

Materials.

Method, Conclusions, and Discussion. — **1.** What fractional part of the whole surface of the demonstration globe can you see at one time? What fraction of the earth's surface, therefore, does the sun shine upon at one time?

2. Imagine that you are on the demonstration globe and that some distant object in the room is the sun; keep in mind the fact that one must look toward the east to see the sunrise. Determine whether the earth rotates clockwise or counter-clockwise.

The demonstration globe is rotating *clockwise* when, as one faces it, any point upon its surface moves from the right of the observer to the left. This is in accordance with the motion of the hands of a clock as they pass from four to eight, when the clock is on its back with the bottom of the dial toward the observer. Accordingly, the demonstration globe is rotating *counter-clockwise* (or anti clockwise) when, as one faces it, any point upon its surface moves from left to right of the observer.

3. Keeping in mind that 1° of longitude or latitude = 60′ of longitude or latitude, and that 1′ of longitude or latitude = 60″ of longitude or latitude, fill out the following table:

In one day, that is, one complete rotation, or twenty-four hours, the sun shines upon — ° — ′ — ″ of longitude.

In one hour of time, or one twenty-fourth of a rotation, the sun shines upon — ° — ′ — ″ of longitude.

In 4 min. of time, the sun shines upon —° —′ —″ of longitude.

In 1 min. " " " " " " __° __′ __″ " "

In 4 sec. " " " " " " __° __′ __″ " "

In 1 sec. " " " " " " __° __′ __″ " "

4. Imagine that a knife cuts through the earth from pole to pole, with the point following down the axis. If the knife made one of these cuts, always from the same direction, *at the end of every hour* during the twenty-four which comprise a complete rotation or day, how many cuts would there be in the globe after one complete rotation? These cuts on the earth would correspond with the meridians of longitude which are marked on every globe and map.

5. Why, therefore, are the meridians drawn on a globe sometimes called hour circles? (Remember that while only these few meridians are usually drawn on a globe, there could be an infinite number of them — in fact, one meridian for every line that could be drawn north and south on the earth.) The meridian which passes through Greenwich, London, is called the zero meridian; and all points east of London are east longitude and those west of London, west longitude. Petrograd, therefore, is on the thirtieth meridian east, and its longitude is 30° E. Adrar, northwestern Africa, is on the fifteenth meridian west, and its longitude is 15° W.

6. What meridian passes through, and what is the longitude of, Cape Farewell, Greenland? Melbourne, Australia?

Diagram. — On the graph paper opposite your report, draw a circle to represent the earth. Draw the axis at an angle of $23\frac{1}{2}°$ from the perpendicular, and omitting geographical features, draw in several meridians of longitude on the globe. Write in their proper places upon the diagram: axis, perpendicular, $23\frac{1}{2}°$, meridian.

No. 3. EXPERIMENT ——

Purpose. — To study the relation between longitude and time in order to solve some problems in longitude and time.

Materials.

Method, Conclusions, and Discussion. — **1.** Consider the 180th meridian as a starting point and your eyes, the sun. Since the earth rotates counter-clockwise, does the sun rise at your city before or after it rises at London? Does it rise at Bombay before or after it rises at London? **2.** When it is noon at London, is it A.M. or P.M. at Philadelphia? At Rome, Italy? **3.** In Question 3 of the preceding experiment you found that

1 hr. of time	corresponds to	—° of longitude.
1° of longitude	"	" — min. of time.
1 min. of time	"	" —′ of longitude.
1′ of longitude	"	" — sec. of time.
1 sec. of time	"	" —″ of longitude.
1″ of longitude	"	" — sec. of time.

4. Referring to the preceding table, determine exactly how much time, in hr., min., and sec., sunrise is earlier or later at Portland, Oregon, the longitude of which is 122° 40′ 0″ W., than at London. **5.** The longitude of Philadelphia is 75° 10′ 0″ W. How much earlier or later is sunrise at

Philadelphia than at Portland, Oregon? **6.** When it is exactly 2 : 30 P.M. at Philadelphia, sun time, it is 11 : 20 : 52 at San Francisco, Cal. Find the exact longitude of San Francisco. **7.** Will the *clocks* at Petrograd, Russia, show an earlier or a later time than the *clocks* at Philadelphia? How much earlier or later? (Consider the longitude of Petrograd to be exactly 30° E.)

No. 4. EXPERIMENT ——

Purpose. — To learn what is meant by Standard Time, and to determine some advantages of Standard Time.

Materials.

Method, Conclusions, and Discussion. — **1.** In which time belt do you live? Is your Standard Time earlier or later than your sun time? Why is there this difference? **2.** Why is Standard Time more convenient for railroads and steamboats than sun time? **3.** When a person travels east, does he set his watch ahead or back? How far east or west must he go before his watch is one hour *fast?* **4.** If a man were to travel *west* entirely around the earth, how would he have to change his date in order to make up for loss or gain in time ? How would he change his date if going east entirely around the earth? These changes are made at the time when the vessel crosses the International Date Line. **5.** How would the date have to be changed on a vessel crossing the International Date Line from the eastern side to the western, April 30? Crossing it from the western side to the eastern? **6.** If a ship should cross the International Date Line from the east side to the west side, one minute after noon, Wednesday, what time and day would it immediately be considered to be on the ship? If a ship crossed from the west to the east side? What day and time,

from the point of view of the people on the ship, would it be then at London in each case?

Diagrams. — **1.** On an outline map of the United States, draw the Standard Time belts, and shade every other belt. Draw the meridian which passes approximately through the middle of each belt. Label each belt with its appropriate name. **2.** On an outline map of the world draw the International Date Line. Just east of this line write "Wednesday," and west of the line write the correct day, "Thursday" or "Tuesday."

No. 5. EXPERIMENT ——

Purpose. — To determine the cause of the seasons of the year; the reason why the equator, the tropics of Cancer and Capricorn, and the arctic and antarctic circles are located where they are; and to determine the relation of the seasons of the year to the number of hours of daylight and darkness at different places on the earth.

Materials.

Method, Conclusions, and Discussion. — **1.** How much of the equator is illuminated at one time on this date? **2.** Since the sunrise is in the east, must the earth rotate clockwise or counter-clockwise, as you look at it from above? **3.** On March 21, how many hours of daylight and of darkness would *any* place on the equator have? Your home? Any place on latitude 76° S.?

A[1] ----------

4. Where do the vertical rays of the sun fall, June 21? **5.** What, therefore, determines the location of the tropic of Cancer? **6.** How many degrees beyond the north pole,

[1] The students are to insert at A, B, and C, directions in accordance with the plan outlined in the TEACHER'S MANUAL, p. 8.

and how many degrees south of the equator do the rays of the sun fall, June 21? **7.** How many hours of daylight and of darkness are there on the equator, June 21? **8.** Counting the distance between two adjacent meridians as representing one hour, how many hours of daylight and of darkness would there be at any point on latitude 40° S., and at Philadelphia, Pa., June 21?

B

9. What name is given the date now represented by the relative positions of earth and sun? **10.** How many hours of daylight and of darkness will there now be at your home? At Tierra del Fuego? On the equator?

C

11. Upon what circle do the sun's vertical rays now strike? What, therefore, determines the location of the tropic of Capricorn? How many degrees north or south of the equator is it? **12.** How many hours of daylight and of darkness are there now at the equator? At your home? At the north pole? At the south pole? **13.** How many degrees is your home from the vertical rays of the sun, June 21? How far is it from the point farthest from the equator, where the sun's rays strike at noon, June 21? **14.** How many hours of daylight and of darkness are there any day of the year on the equator?

Diagram. — On the graph paper opposite your report, draw an ellipse nearly as long as your paper is wide. Let this represent the earth's orbit. Draw a small circle a little to the right of the center of this ellipse to represent the sun. Now at each of the four points in the orbit which correspond to the position of the earth on March 21, June 21, September 22, and December 22, draw a small circle to represent the earth, showing in each case the tilt of the earth's axis. Draw

in the tropics of Cancer and Capricorn, the equator and the arctic and antarctic circles, and shade the part of the earth which is in shadow on these dates. Also draw a vertical line from the sun to the point on the earth where the sun's vertical rays strike on each of the above dates. Write neatly upon the diagram in their proper places the following terms: sun, earth's orbit, March 21, June 21, September 22, December 22.

No. 6. EXPERIMENT ——

Purpose. — To determine how long it takes the moon to make a rotation upon its axis as compared with its time of revolution about the earth.

Materials.

Method.

Conclusion. — If it takes twenty-eight days for the moon to complete a revolution, how many days does it take it to make a complete rotation?

No. 7. EXPERIMENT ——

Purpose. — To study the revolution of the moon in order to determine how much of the moon is visible from the earth at each lunar phase.

Materials.

Method.

Conclusions. — **1.** What fraction of the moon's surface is illuminated throughout a complete revolution? **2.** How much of the moon is visible at new moon? Explain. **3.** At first quarter? Explain. **4.** At full moon? Explain. **5.** At third quarter? Explain.

Discussion. — **1.** In what direction must we look in the early evening in order to see the moon just after new moon? At full moon? **2.** How many days elapse between consecutive phases of the moon? **3.** Between what lunar phases is a crescent moon visible? Do the crescent horns always face in the same direction? Explain. **4.** At what phase or phases of the moon are lunar eclipses possible? Solar eclipses? Do lunar and solar eclipses occur every time the moon reaches the corresponding phase? Explain. **5.** Explain fully the cause of a partial lunar and solar eclipse and of an annular solar eclipse. **6.** Between what phases is the moon gibbous? Between what phases is the moon waxing? Waning? **7.** Mercury and Venus have always the same side toward the sun. How many times do these planets rotate during one of their revolutions, or years?

Diagram. — On the graph paper opposite your report draw a large circle to represent the moon's orbit, as viewed from above. In the center draw a small circle (*E*) to represent the earth. At the right-hand margin of the paper, opposite the earth, draw another small circle (*S*) to represent the sun. On the large circle between *E* and *S* draw a small circle to represent the moon, and at each quarter of the distance around the orbit, starting at this point, draw another circle the same size, to represent the moon at another phase. Divide each circle representing the moon into quarters, and label them *A*, *B*, *C*, and *D*, in accordance with the positions of the corresponding quarters of the moon at its different phases as illustrated by the experiment. Shade the unilluminated quarters in each case, and label the diagram with the following terms: new moon, first quarter, full moon, third quarter, *E*, *S*. Place arrows beside the orbit to indicate in which direction the moon revolves.

No. 8. EXPERIMENT ——

Purpose. — To determine (I) how many centimeters there are in one inch, and (II) how many inches there are in one meter.

Materials.

Methods. — I and II.

Conclusions. — **1.** How many centimeters were there found to be in one inch? **2.** How many inches were there found to be in one meter?

Discussion. — **1.** What results would you have obtained had your measurements and computations been absolutely accurate? **2.** What causes can you see in your work to make your results inaccurate? **3.** One inch equals how many mm.? How many dm.? How many Dm.? How many Km.? How many Hm.? How many Mm.? **4.** How much ought a metric ton of sugar to cost if a hundred-pound sack costs $6.60?

Diagrams. — **1.** On your graph paper opposite the report, draw a diagonal line 12 cm. long and mark off on opposite sides of it the cm. and in., numbering each. **2.** On a similarly drawn diagonal line 3 in. long, mark off the cm. on one side of the line, and in. on the other, numbering each.

No. 9. EXPERIMENT ——

Purpose. — To compute from measurements in metric units (I) the surface of one face of a block, and (II) the volume of the block.

Materials.

Method.

Conclusions. — **1.** What was the area of the face of the block in sq. mm.? In sq. cm.? In sq. dm.? In sq. m.?

In sq. Dm.? In sq. Hm., or ha.? In sq. Km.? In sq. Mm.? **2.** What was the volume of the block in cu. mm.? In c.c.? In cu. Dm.? In cu. dm.? In cu. m.? In cu. Km.? In cu. Mm.? In cu. Hm.?

Discussion. — **1.** How many sq. mm. are there in 7 sq. cm.? **2.** How many cu. mm., in 7 c.c.? **3.** How many sq. mm., in 7 sq. m.? **4.** How many c.c. in 7 cu. m.? **5.** How many c.c. in 7 liters? **6.** How many l. in a bin of 7 cu. dm. capacity? **7.** In this experiment, if the block had been a rectangular bin or tank with the same dimensions, how many l. would it have contained? How many ml.? dl.? cl.? Kl.? Dl.? Ml.? Hl.?

No. 10. EXPERIMENT ——

Purpose. — To learn to represent forces such as pushes and pulls, graphically, that is, by means of diagrams; and to represent some given forces graphically.

Materials.

Method.

Conclusions. — What three things must be known before one can represent a force graphically?

Diagrams. — **1.** On the graph paper opposite your report, diagram a force of 20 Kg., acting east from a given point. Scale, 3 mm. = 1 Kg. **2.** Similarly, represent two forces, 5 Kg., and 30 Kg., acting respectively north and east upon the same point. Write neatly upon the figure in its proper place, "point of application," and indicate by an arrow point the direction in which the force was exerted. Also indicate the scale.

No. 11. EXPERIMENT ——

Purpose. — To learn how to determine graphically the resultant of two forces acting at right angles to each other, and to determine in this way the resultant of a pair of forces acting at right angles to each other.

Materials.

Method and Conclusions. — Describe fully how one goes about finding the resultant of two forces acting at right angles to each other.

Discussion. — 1. A ball is tossed south with a force of 10 Kg., across a street running east and west. A west wind blows upon the ball during its flight, with a force of 7 Kg. By means of a diagram drawn on the graph paper, find the direction, and the value of the resultant of the two forces acting upon the ball, other than gravity, which finally pulls the ball to the ground. Scale, 3mm. = 1 Kg. **2.** One boy pulls on his wagon with a force of 8 Kg., while his brother pushes on the wagon from behind in the same direction with a force twice as great. Without making a diagram, determine what the value of the resultant of this push and pull would be, and in what direction it would act. **3.** What would be the resultant and the direction of motion in the last problem, if both boys were *pulling* in opposite directions upon the wagon?

Diagram. — Complete the rectangle in the second diagram, made for No. 10, and find the direction and value of the resultant. Use the same scale as above. Write neatly upon this diagram in their proper places the following terms: point of application, force (two places), resultant. Indicate by arrowheads, at the end of the line, the direction in which each force and the resultant act.

No. 12. EXPERIMENT ——

Purpose. — In a lever of the first class, that is, one in which the balancing point or fulcrum (f) is between the acting force (F) and the weight to be lifted (W), to determine whether a heavier weight can be lifted with a given force when F is applied at a point nearer or farther from f.

Materials.

Method.

Conclusion. — Using a lever of the first class, can one lift a heavier weight with a given force when the force is applied at a point nearer the balancing point or farther from it?

No. 13. EXPERIMENT ——

Purpose. — In a lever of the second class, that is, one in which W is between F and f, to determine whether a greater force (F) is required to lift a given weight (W) when W is nearer f or farther from it.

Materials.

Method.

Conclusion. — Using a lever of the second class, in order to be able to lift a given weight with the least possible effort, should one place the weight nearer the balancing point or farther from it?

No. 14. EXPERIMENT ——

Purpose. — In a lever of the third class, that is, one in which F is between f and W, to determine whether less force is required to lift a given weight when F is applied at a point nearer f or farther from it.

Materials.

Method.

Conclusion. — Using a third-class lever, in order to lift a given force with the least possible effort, should one exert the force at a point nearer the balancing point or farther from it?

Discussion. — **1.** Using a lever of the first class, if you could grasp the lever in only one place, or if the lever arm upon which you were exerting the force were very short, in which direction, toward or away from the weight, should you shift the fulcrum in order to lift the weight with the least effort? **2.** Classify the following levers and indicate in each case what corresponds to *F*, *f*, and *W*: (*a*) a fish pole, (*b*) a wheelbarrow, (*c*) an oar, (*d*) a nutcracker, (*e*) a case knife when used to cut meat, (*f*) a seesaw, (*g*) scissors. **3.** How may a crowbar be used either as a first-class or a second-class lever in rolling a log? **4.** Does a child, swinging on a gate, strain the hinges more when he is near them or farther out on the gate? **5.** In which class of levers is *F* always greater than *W*?

Diagrams. — Diagram each class of levers you experimented with, and write neatly upon each diagram in the proper place the following: *F*, *f*, *W*.

No. 15. EXPERIMENT ——

Purpose. — To determine the actual amount of work done by the acting force (*F*) and the useful work done upon the resisting force or weight lifted (*W*) in the case of a simple machine such as a single fixed pulley.

Materials.

Method.

Conclusions. — **1.** What was the actual work done by the acting force? **2.** What was the useful work done upon the resisting force?

Diagram the apparatus as set up in the experiment, and write neatly upon the diagram in their proper places the following terms: single fixed pulley, support stand, W, F.

No. 16. EXPERIMENT ——

Purpose. — From the data obtained in No. 15, to determine the efficiency of a simple machine such as a single fixed pulley.

Method.

Conclusion. — What was the efficiency of the pulley as used in No. 15?

No. 17. EXPERIMENT ——

Purpose. — From the data obtained in No. 15, to determine the actual mechanical advantage of the single fixed pulley, and to determine the actual mechanical advantage of a single movable pulley.

Materials.

Method.

Conclusions. — **1.** What was the mechanical advantage of the single fixed pulley? **2.** Of the single movable pulley?

Discussion. — **1.** Since, because of friction, in the case of the single fixed pulley, F is always greater than W, what convenience would there be in using a single fixed pulley? **2.** Why was the efficiency of the pulley less than 100 %? Would the efficiency of any machine ever be 100 %? Explain. **3.** Name the six simple machines.

Diagram. — Diagram the apparatus as set up in the experiment, and write neatly upon the diagram the following terms in their proper places: single movable pulley, support stand, F, W.

No. 18. EXPERIMENT ——

Purpose. — To determine the volume of an irregular solid which will not dissolve in water.

Materials.

Method.

Conclusion. — What was the volume of the —— found to be?

No. 19. EXPERIMENT ——

Purpose. — To determine the density of the solid used in No. 18.

Materials.

Method.

Conclusion. — What was the density of —— found to be?

No. 20. EXPERIMENT ——

Purpose. — To determine the density of ——.

Materials.

Method.

Conclusion. — What was the density of —— found to be?

Discussion. — **1.** If you were given the weight and the diameter of a metal ball, how could you compute the density of the metal, knowing that the volume of the ball is $\frac{1}{6}\pi D^3$ or $\frac{1}{6}(3.1416D^3)$? **2.** The density of sea water is practically the same at the bottom of the ocean as at the top. Would a stone dropped into the ocean, therefore, ever sink to the bottom? **3.** Why do canned berries frequently collect at the top of the jar? **4.** What does the fact that the warmest air is near the ceiling of a room tell you regarding the comparative density of warm and cool air? **5.** What is the difference between density and specific gravity?

No. 21. EXPERIMENT ——

Purpose. — To determine what effect heating and cooling a solid body has upon the volume of the body.

Materials.

Method.

Conclusion. — How does heating and cooling a solid affect its volume?

No. 22. EXPERIMENT ——

Purpose. — To determine what effect heating and cooling a liquid has upon its volume.

Materials.

Method.

Conclusion. — How does heating and cooling a liquid affect its volume?

Diagram. — Draw the apparatus as used in the experiment, and write neatly upon the diagram in their proper places the following terms: Florence flask (or test tube), glass tube, water, burner, support stand, water level before heating, water level after heating.

No. 23. EXPERIMENT ——

Purpose. — To determine what effect heating and cooling a gas has upon its volume.

Materials.

Method.

Conclusion. — How does heating and cooling a gas affect its volume?

Discussion. — **1.** How does heating and cooling a body affect the density and specific gravity of the body? **2.** At

what time of year is wire clothesline apt to need tightening? Explain. **3.** Why does the milkman not fill the milk-bottles entirely full of very cold milk, especially on a summer morning? **4.** Is there more mercury in a thermometer at 100° than at 0°? To what is the difference in level of mercury due? **5.** Explain in terms of molecules what happens when a body is heated or cooled. **6.** The first thermometer was invented by Galileo in 1592. It consisted essentially of an inverted round bottom flask, with a long neck of small diameter or bore. This neck was always more or less full of colored liquid, and had its open end extending vertically down into an *open* vessel. Why would it roughly indicate temperature changes? Why was it very inaccurate? **7.** Why do rocks exposed to the sunlight sometimes break, and also why do rocks which have been in the sun all day sometimes break at night?

Diagram. — Draw the apparatus used in the experiment, and write neatly upon the diagram in their proper places the following terms: burner, flask, tube, air, water.

No. 24. EXPERIMENT ——

Purpose. — To determine the effect of filtering dirty water.

Materials.

Method.

Conclusion. — What did the appearance of the filtrate indicate as to the effect of filtering dirty water?

Diagram. — Draw the apparatus with which you did the filtering, and write neatly in their proper places the following terms: support stand, funnel, beaker or tumbler, filter paper, filtrate.

No. 25. **EXPERIMENT ——**

Purpose. — To determine the effect of boiling dirty and impure water, and then condensing the vapor and collecting the distillate.

Materials.

Method.

Conclusion. — What did the appearance of the distillate indicate regarding the effect upon dirty water of boiling it and condensing the vapor?

Discussion. — **1.** What sort of impurities does filtering fail to remove? **2.** Name some ways in which dirty water thrown into a yard is purified by nature. Why should such water never be thrown near a water supply, such as a stream, well, or cistern? **3.** Briefly describe how city water is purified. **4.** By which of the above processes can the purer water be obtained? Explain. **5.** How may fresh water be prepared at sea from sea water? **6.** What is the function of the water jacket on the condenser? **7.** Explain fully how nature prepares fresh water. **8.** What in nature's process corresponds with the following features of No. 25: the burner, the flask of dirty water, the water jacket, the inner condensing tube, the distillate? **9.** In nature does water filter more readily through clay or sand? Explain.

Diagram. — Draw the condensing apparatus, and write neatly upon the apparatus the following terms: condenser, burner, water jacket, distillate, support stand, impure water, intake and outlet (on water jacket).

No. 26. EXPERIMENT ——

Purpose. — To determine whether a given thermometer is accurately marked as regards its boiling point.

Materials.

Method.

Conclusion. — Does the boiling point on the thermometer vary from the correct temperature, and if so, by how much?

Diagram. — Draw the apparatus, and write neatly in their proper places the following terms: thermometer, burner, boiling water, flask, support stand.

No. 27. EXPERIMENT ——

Purpose. — To determine whether a given thermometer is accurately marked as regards its freezing point.

Materials.

Method.

Conclusion. — Does the freezing point on the thermometer vary from the correct temperature?

Discussion. — **1.** Will the boiling point in Death Valley, California, which is 276 ft. below sea level, normally be above or below 100° C.? Explain. **2.** Potatoes can be cooked in Boston, which is almost at sea level, in about half the time it takes to cook them in Cripple Creek, Colorado, the altitude of which is about 10,000 ft. Explain. **3.** Since the boiling point of water is ordinarily 212° F., or 100° C., does increasing the gas flame or the wood fire under a kettle of boiling vegetables cause them to cook any faster? Does it cause them to boil dry any more quickly? Explain.

Diagram. — Draw the apparatus, and write neatly in their proper places the following terms: thermometer, pulverized ice or snow, tumbler or beaker.

No. 28. EXPERIMENT ——

Purpose. — To determine whether, in general, a warm or a cold liquid solvent will dissolve the greater weight of solid solute, and to determine whether a solution is roily or clear.

Materials.

Method.

Conclusions. — **1.** Since the above are typical examples of solutions, does the hot or the cold liquid solvent dissolve the greater quantity of solid solute? **2.** If these are typical solutions, is a solution roily or clear?

No. 29. EXPERIMENT ——

Purpose. — To determine whether, in general, a warm or a cold liquid solvent will dissolve the greater quantity of gaseous solute (in this case, air).

Materials.

Method.

Conclusions. — **1.** If this is a typical case, will a warm or a cold liquid solvent dissolve or hold in solution the greater quantity of gaseous solute? **2.** As the temperature of a liquid solvent is raised, what is the resulting change in (*a*) the quantity of *gaseous* solute which the solvent will dissolve, (*b*) the quantity of *solid* solute?

No. 30. EXPERIMENT ——

Purpose. — To determine two conditions under which solid crystals separate out of, or are deposited from, a liquid solution.

Materials.

Methods. — I and II.

Conclusions. — **1.** Did the liquid solution, when cooled, hold more or less or the same quantity of solid solute?

2. State, therefore, one condition under which crystals separate out of a solution. **3.** As the solution evaporated, did it hold more or less or the same quantity of solute? **4.** State, therefore, a second condition under which crystals separate out of a solution.

Discussion. — 1. Name the solvent and the solute in each case in the above three experiments. **2.** Name at least four respects in which a solution may differ from the solvent. **3.** Keeping in mind the conclusions to No. 30 above, account for the increasing saltiness of Great Salt Lake, and for the salt deposits upon the margin of this lake. **4.** Explain under what conditions salt lakes are formed. **5.** Account for the great salt deposits found in various parts of the United States. **6.** Many rocks are slightly soluble in water. Explain, therefore, the expression "constant dripping of water wears away a stone." **7.** How do fish obtain the oxygen which they need? Why would fish be apt to die in water which had been recently boiled, even though subsequently cooled? **8.** Why is ground-water never pure? Name some impurities which it may contain. **9.** What is a mineral spring? **10.** Explain fully how limestone caves and natural bridges are formed. **11.** Explain fully how stalactites and stalagmites are formed. **12.** A *physical* or *simple solution* is one from which the solute can be recovered in its *original form* by the methods illustrated in No. 30. A *chemical solution* is one in which a *new chemical substance* results, which can be separated from the solvent. What kind of solution results, therefore, from dissolving zinc in hydrochloric acid, as, for instance, in the simple cell? Explain. What kind of solution, therefore, is the ocean? **13.** Name at least three minerals, aside from those used in this experiment, which form crystals. **14.** Are snow and ice crystals formed by either of the two conditions determined in No. 30? Explain.

No. 31. EXPERIMENT ——

Purpose. — To determine how heat is transferred from one place to another in the air, by convection.

Materials.

Method.

Conclusions. — **1.** Did the heat seem to travel from particle to particle, that is, from molecule to molecule, or in currents or large bodies of molecules? **2.** Since this experiment furnishes a good example of convection in gases, what, therefore, would be a good definition of convection in gases?

Diagram. — Draw the apparatus, and write neatly the following terms in their proper places: convection box, candle. Indicate by arrows the direction of the movement of the air in the convection box.

No. 32. EXPERIMENT ——

Purpose. — To determine how heat is transferred from one place to another in water, by convection.

Materials.

Method.

Conclusions. — **1.** Did the heat seem to travel from molecule to molecule, or in currents or large bodies of molecules? **2.** Since this is a good example of convection in liquids, what, therefore, would be a good definition of convection in liquids?

No. 33. EXPERIMENT ——

Purpose. — To determine how heat is transferred from one place to another in solids, by conduction, and to determine which of several metals is the best heat conductor.

Materials.

Method.

Conclusions. — **1.** Since in solids the particles or molecules merely vibrate and are not free to travel about as in liquids, which is more probable, that the heat passed along the wires from molecule to molecule, or that the heat was transferred as in the two preceding experiments, by the movement of large bodies of molecules? **2.** What, therefore, would be a good definition of conduction in solids? **3.** Name the different metals of the conductometer in order of their heat conductivities.

Diagram. — Draw the conductometer, and write neatly in their proper places the following terms: conductometer, Fe, brass, Al, Cu, burner.

No. 34. EXPERIMENT ——

Purpose. — To determine whether heat is transferred more readily in water by convection or by conduction.

Materials.

Method.

Conclusion. — Is heat transferred more readily in water by convection or by conduction?

Discussion. — **1.** Explain fully *why* the currents moved as they did in No. 31. **2.** Explain fully how No. 31 illustrates the cause of winds and air currents, such as, for instance, land and sea breezes. **3.** Explain fully how water is heated in a kitchen hot-water heater or gas heater. **4.** Explain fully why it is advantageous to put ice into the *top* of a refrigerator. **5.** Why is more dust apt to collect above hot-air registers, and hot-water and steam radiators than elsewhere in the room? **6.** Will food heat more quickly in an iron or in an aluminum pan?

7. Out of which could one drink hot coffee more comfortably, a porcelain or an aluminum cup? Why? **8.** Comparing the last two experiments above, which do you infer to be the better conductor of heat, a liquid or a metal? **9.** The stopper of a glass-stoppered bottle and a fruit jar cover may often be loosened by dipping the neck of the jar or bottle into hot water. Explain. **10.** Why should fruit jars be heated before hot fruit is poured into them? **11.** Describe fully how a thermos bottle is constructed and explain fully why it keeps a warm substance warm, and a cold substance cold. **12.** Why will a thermos bottle keep a substance cool longer than it will keep one hot? **13.** Explain fully the principle upon which fireless cookers are built.

No. 35. EXPERIMENT ——

Purpose. — Using equal weights of several different substances at the same temperature, to determine which of them contains the greatest quantity of heat.

Materials.

Method.

Conclusions. — Name the substances used, in order of their ability to take up and hold heat, placing first the one that contained the greatest quantity of heat per gram.

Discussion. — **1.** Weight for weight, which would make the more efficient foot warmer, hot water or a flatiron, provided that both were at the same temperature to start with? Explain. **2.** If balls of the same weight, but made of different metals, were first heated to the same temperature by placing them in boiling water, and were then placed upon a block of paraffin, would all of them melt the same quantity of the paraffin? Explain. **3.** Water has a greater capacity for absorbing and retaining heat than any other liquid or solid.

Explain how this fact in part accounts for the phenomenon that the changes of temperature of the land between day and night, and between winter and summer, are much greater than those of the ocean, with the result that oceanic islands undergo less extreme temperatures than inland regions. **4.** A pound of water and a pound of iron are both placed in equal sunshine for the same length of time. Which will be warmer? Explain. **5.** The method by which the different substances were heated to the same temperature in this experiment employs the same principle as the double boiler used in cooking such foods as will "burn" if raised to too high a temperature while cooking. Why does the double boiler insure the proper cooking of such substances?

Diagram. — Make a neat diagram showing the method by which each of the substances was heated prior to its being dropped into the tumbler of water. Write the following terms in the proper places on your diagram: burner, outer vessel of double boiler, inner vessel of double boiler, substance to be heated, thermometer, water, stand.

No. 36. EXPERIMENT ——

Purpose. — To determine how a liquid behaves when brought into contact with a porous substance.

Materials.

Method.

Conclusions. — **1.** What did the liquid (ink) do when in contact with the porous substance (the loaf sugar)? **2.** With the non-porous substance (the powdered sugar)?

Discussion. — **1.** Why did the ink rise in the loaf sugar, while the powdered sugar remained dry? **2.** Why does water rise through sandy soil more readily than through clay? **3.** How, therefore, does soil lose much of its mois-

ture? **4.** In dry farming, why does the farmer make a mulch by finely pulverizing the top soil? If he did not, what would be the result? **5.** Why, in some regions, can "dry farmers" raise only one crop every two years? **6.** By what process does sap rise in plant stems? **7.** Through what part of the stem does the sap ascend? **8.** By what two processes are solutions circulated to all parts of plants? **9.** Why could water be wiped up more easily with a cloth than with newspaper? **10.** Explain how the flame of a lamp is constantly supplied with oil through the wick.

Diagram. — Draw the apparatus, and write neatly in their proper places the following: porous loaf sugar, non-porous powdered sugar, plate, ink. Shade the portion which was colored by the ink.

No. 37. EXPERIMENT ——

Purpose. — To determine what happens (I) when alcohol and water occupy different portions of the same vessel, and (II) when a crystal of —— is left for some time in water.

Materials.

Methods. — I and II.

Conclusions. — **1.** If it is considered that all substances are composed of infinitesimally small particles (spheres) called *molecules*, which are constantly in very rapid motion in *every direction*, how may the results of I be accounted for? **2.** The results in II?

Diagrams. — **1.** Make two drawings of the test tube, one showing the appearance of the contents before diffusion took place, and the other showing the appearance of the contents afterwards. Write neatly in their proper places the following terms: alcohol, water, ring, alcohol and water. **2.** Similarly, make two drawings of the second test tube, one

showing the appearance of the contents before diffusion took place, and the other showing the appearance of the contents afterwards. Write neatly in their proper places the following terms: crystal, water, solution.

No. 38. EXPERIMENT ——

Purpose. — To determine what happens when two different gases, such as air and ——, are separated from each other only by a porous wall.

Materials.

Method.

Conclusions. — **1.** If it is considered that both the —— and the air molecules are so small that they pass easily back and forth through the pores of the porous cup, almost without interfering with each other, and that the —— molecules move much more rapidly than the air molecules, would the pressure inside the cup soon become greater or less than the air pressure on the surface of the water in the beaker? To begin with, of course, the pressure inside the porous cup is the same as that outside. **2.** What, therefore, caused the evolution of the bubbles from the porous cup out at the end of the tube?

Discussion. — **1.** Explain why the odor of ammonia becomes noticeable throughout a room soon after a bottle of ammonia water is uncorked in the room. **2.** Which is denser, alcohol or H_2O (water)? Why do you think so? **3.** In No. 38, did no air diffuse from the porous cup out into the bell jar? Explain. **4.** In the light of the conclusion of No. 38, would the pressure in the cup have become greater or less than that of the air on the surface of the water, if the *cup* had been filled with —— and the jar with air? What then would probably have happened?

Diagram. — Draw the apparatus used in this experiment, and write neatly in their proper places the following terms: support stand, porous cup, bottle or tumbler, water, *the name of the gas you used,* bell jar or jar, air.

No. 39. EXPERIMENT ——

Purpose. — To determine whether air has weight.
Materials.
Method.
Conclusion. — Has air weight or not? Give reasons for your answer.

No. 40. EXPERIMENT ——

Purpose. — To determine whether air exerts pressure.
Materials.
Method.
Conclusion. — Does air exert pressure? Why do you think so?

Discussion. — **1.** What was in the light globe before the tip was broken off? **2.** State reasons why your numerical results were probably inaccurate. **3.** Explain fully why the globe was filled with water or the can crushed, using the following expressions: "partial vacuum *or* reduced pressure," "forced," "greater pressure," "less pressure." Avoid the use of the following: "sucked in," "drew in," and "pulled in." **4.** To what is the pressure of atmosphere or water due? **5.** If the globe had been smashed inside the bag instead of merely having had the tip broken off, would the final result have differed? Explain. **6.** Why was *cold* water poured over the sealed can? **7.** How do you account for the fact that the boiling continued inside the can even when cold water was poured upon the can?

Diagram. — Draw the can as well as you are able, as it appeared before and after the action of the air pressure upon it, and write neatly in their proper places the following terms: partial vacuum, atmospheric pressure, can before being crushed, can after being crushed.

No. 41. EXPERIMENT ——

Purpose. — To construct and study a simple barometer in order to determine what supports the mercury (Hg) column in the tube of a simple barometer.

Materials.

Method.

Conclusions. — **1.** After the Hg column subsided in the tube, what was above the Hg in the tube? **2.** What, therefore, supported the column of Hg in the tube?

Discussion. — **1.** How does the weight of the Hg column compare with the weight of the air column of the same diameter as the Hg column, but extending up as high as the air goes? **2.** What would have happened if the top of the barometer tube had been broken off after the barometer was constructed? Explain. **3.** How high would the Hg column have stood, had the whole experiment been performed in a vacuum? Explain. **4.** How would the height of a barometer column change if taken up a high mountain or down in a mine? Explain. **5.** Could a simple barometer, similar to this one, be constructed using water, or gasoline, instead of Hg? What changes, if any, would be necessary in the length of the closed tube before a successful attempt to construct such a barometer could be made? Explain. **6.** Explain what causes the lemonade to be conveyed to the mouth, when one drinks it through a straw.

Diagram. — Draw the simple barometer as it was made

for this experiment, and write neatly in their proper places the following terms: barometer column, beaker, Hg. Write beside the column the height of the Hg column in cm. and in.

No. 42. EXPERIMENT ——

Purpose. — To learn how water may be siphoned from one vessel to another, in order to ascertain what determines the direction in which the water is going to flow; and to determine whether the rate with which the water flows through the siphon is affected by increasing or diminishing the difference between the surface levels of the two vessels.

Materials.

Method.

Conclusions. — **1.** The water levels in two vessels being different, what determines the particular vessel from which the water will be siphoned? **2.** If the difference in the water levels in the two vessels is increased or diminished, what effect is produced upon the speed with which the water flows through the siphon?

Discussion. — **1.** In a vacuum, could water be siphoned from one vessel to another? Could water be raised by a lift pump in a vacuum? Explain. **2.** A siphon will not lift water over an elevation of more than 34 ft., but it will lift alcohol over a greater elevation. Explain. **3.** Over how high an elevation could mercury be siphoned? Explain. **4.** The great physicist, Pascal, demonstrated that a siphon would not run if the bend in the arm were more than 34 ft. above the upper water level, but that the water would flow if the siphon were inclined sidewise until the bend was less than 34 ft. above this level. Explain. **5.** Why does the lower end of the tube correspond to the water level of a lower vessel, when the

water does not flow into a lower vessel? **6.** Explain fully why water continues to flow through a siphon. **7.** If the water levels in both vessels were the same, what would happen? Explain. **8.** Why does not the liquid column part at the top and flow both ways, emptying the siphon? **9.** If you were given a piece of garden hose, how could you empty the hot water from a wash boiler on the stove, without bailing out, or lifting off, the boiler?

Diagram. — Make a neat diagram of the siphon in action. Write the following terms in their proper places upon the diagram: upper water level, lower water level, siphon, beakers or tumblers (whichever you used).

No. 43. EXPERIMENT ——

Purpose. — To study a lift pump in order to determine how and why the valves open and close.

Materials.

Method.

Conclusions. — **1.** Did both valves open and close at the same time? **2.** Explain fully why the valves open and close as they do. Avoid using the following expressions: "the water rises," "suction," "valve rises" or "valve opens," "water is drawn into the pump"; but be sure your answer contains these: "partial vacuum *or* reduced pressure," "piston chamber," "pressure of the air *or* air pressure." **3.** Does the water flow continuously or intermittently in this form of pump?

Discussion. — **1.** Could water be raised by a lift pump in a vacuum? Explain. **2.** The valves of an ordinary hand lift pump are usually packed with leather which *shrinks* when it becomes *dry*. Why, therefore, is it frequently necessary to "prime" the pump, *i.e.* pour water into it, before a flow of

water can be obtained? **3.** If the valve (*a*) were more than 34 ft. above the level of water, the water could not be raised with this kind of pump. Explain. **4.** Criticize this statement: the vacuum cleaner sucks the dirt out of a carpet. Justify your criticism.

Diagrams. — Make two diagrams of the pump model in the tumbler of water, one showing which valve is up when the piston is ascending, and the other showing which valve is up when the piston is descending. Letter the upper valve in both diagrams (*a*) and the lower one (*b*) and place beside each diagram an arrow indicating whether the piston is ascending or descending. Place the following terms in their proper places on the diagrams: piston, piston chamber, partial vacuum, valve, spout, water, air pressure (draw arrows to indicate where the air pressure is exerted). Indicate in which diagram water is flowing from the spout.

No. 44. EXPERIMENT ——

Purpose. — To determine the dew point of the atmosphere in the room.

Materials.

Method.

Conclusions. — **1.** To what temperature was the air in the immediate vicinity of the vessel cooled when moisture began to be precipitated as dew? **2.** To what temperature, therefore, would the room have to be cooled before the moisture in the air would begin to precipitate as dew?

Diagram. — Draw the apparatus used in the experiment, and write neatly in their proper places the following terms: tin cup, chipped ice and water, dew, thermometer. If the dew-point apparatus is used, diagram it neatly, and indicate by dotted lines the level of ether in the vessel, and

to what points in the vessel the thermometer, pipette, and tube from the aspirator bulb extend. Write neatly the following terms in their proper places upon the diagram: pipette, aspirator bulb, thermometer, ether, metal vessel, dew.

No. 45. EXPERIMENT ——

Purpose. — To determine the frost point of the atmosphere in the room.

Materials.

Method.

Conclusion. — To what temperature would the room have to be cooled before the moisture in the air would begin to be precipitated as frost?

Diagram. — Draw the apparatus used in this experiment, and write neatly in their proper places: tin cup, chipped ice, salt and water, frost, thermometer. If the dew-point apparatus is used, write neatly upon the diagram: ether, pipette, aspirator bulb, frost, metal vessel, thermometer. Indicate by dotted lines the level of ether in the vessel, and to what points the pipette, the tube from the aspirator bulb, and the thermometer extend.

No. 46. EXPERIMENT ——

Purpose. — To compute the relative humidity of the atmosphere in the room, from the results of No. 44.

Materials.

Method. — Tell, in complete story form, all that you do in computing the relative humidity, and copy verbatim all that is inclosed by parentheses in the following explanation.

From the table at the bottom of this experiment, find the vapor pressure of water at the room temperature. (This represents the greatest *amount* of water *vapor* the room *could possibly* hold if the temperature of the room remained unchanged.)

Now find the pressure of water vapor at the dew point. (Since dew began to be precipitated at this temperature, this pressure must represent the *actual amount* of vapor in the room. Relative humidity is the per cent of saturation of the space, or in other words, it is the actual amount or pressure of vapor in the space at any given temperature compared with or divided by the amount of pressure of moisture the room or space could contain if it were saturated at that temperature.)

From this explanation, compute the relative humidity in percentage, explaining how you make the computation.

Conclusion. — What is the relative humidity of the room?

TABLE FOR COMPUTING RELATIVE HUMIDITY

This table shows the pressure, P, in centimeters of mercury of the water vapor at the point of saturation for the following temperatures Centigrade.

T.	−10°	−9°	−8°	−7°	−6°	−5°	−4°	−3°	−2°	−1°	0°	1°	2°	3°
P.	.22	.23	.25	.27	.29	.32	.34	.37	.39	.42	.46	.49	.53	.57

T.	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°
P.	.61	.65	.70	.75	.80	.85	.91	.98	1.04	1.11	1.19	1.27	1.35

T.	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	30°
P.	1.44	1.53	1.63	1.74	1.85	1.96	2.09	2.22	2.35	2.50	2.65	2.81	3.15

T.	35°	40°
P.	4.18	5.49

Discussion. — **1.** Define absolute humidity, saturated atmosphere, dew point. **2.** Where did the moisture which

collected on the vessel come from? Why was it deposited? Was all the moisture in the space around the vessel precipitated? **3.** What is the relative humidity of any space which is saturated? **4.** Explain fully what effect raising the temperature of a space would have upon its relative humidity; what effect lowering the temperature of a space would have upon its relative humidity. **5.** Is frost frozen dew? Is snow frozen rain? Justify your answers. **6.** Explain fully under what conditions hail and sleet are formed. **7.** Criticize the statement: Dew falls. **8.** Explain fully why Eastern Oregon and Idaho are semi-arid, while next to the coast there is more abundant rainfall. **9.** What is the most healthful indoor humidity? **10.** How does the air in a living room become "too dry"? **11.** What evil effects are due to excessively dry air? **12.** Why does the temperature need to be higher in a dry room in order that the occupants may be comfortable? **13.** Why is ventilation important to health? **14.** Why are people who live in overheated rooms liable to catch cold?

No. 47. EXPERIMENT ——

Purpose. — To produce fog in order to determine the condition necessary for the production of fog in nature.

Materials.

Method.

Conclusions. — **1.** Keeping in mind that compression of air increases its temperature, and therefore increases the amount of moisture which will evaporate into it, and that expansion cools the air, therefore enabling it to hold less moisture, is fog caused by cooling or by heating of a body or layer of air? **2.** Upon what does fog collect?

Discussion. — **1.** Explain fully why the fog was precipitated when the stopper was removed, using the following terms: compression, evaporation, expansion, relative humidity, precipitation. **2.** Why did not the fog precipitate until the burning match was dropped into the bottles?

Diagram. — Draw a neat diagram of the "fog-bottle" and accessories. Write in their proper places: water, fog, stopper, rubber tubing, compression pump, glass tubing.

No. 48. EXPERIMENT ——

Purpose.— To determine what facts may be learned from a daily weather map.

Materials.

Method, Conclusions, and Discussion. — **1.** Name at least five different items included under the term "weather." **2.** What do the continuous black lines on the map indicate and what are they called? **3.** Approximately what is the pressure at ——, and at ——? **4.** Are differences in pressure for a given distance where the continuous black lines are close together, greater or less than for an equal distance on another part of the map, where the lines are farther apart? Would the wind, therefore, probably be more or less violent where these lines are close together than where they are farther apart? **5.** What is meant by the statement that the barometric pressure is 30 in.? **6.** What do the dotted lines indicate and what are they called? **7.** Name at least five items of information to be found on the *report*, aside from what may be learned from the map itself. **8.** How are rainy areas indicated on the map? **9.** Name at least three practical or commercial benefits which are derived from the publishing of daily weather maps.

Diagram. — Draw the symbols which indicate the following wind and weather conditions: (Note the explanations regarding the wind, in the lower left-hand corner of the map, before drawing the symbols.) (*a*) Partly cloudy with N. W. winds; (*b*) report missing; (*c*) clear with N. E. winds; (*d*) rain and southerly winds; (*e*) cloudy with westerly winds; (*f*) snow with E. wind.

No. 49. EXPERIMENT ——

Purpose. — To determine what facts may be learned from studying a week's weather maps.

Materials.

Method, Conclusions, and Discussion. — **1.** Consulting the Monday map, name the states over which are located the centers of the highs and lows. For convenience, consider the center of a high and low to be where the words "high" and "low" are printed. **2.** In which direction and about how many miles had the lows and highs traveled up to the time the readings for the Tuesday map were taken? Measure from the points where the centers are in each case, and note that the position of the same high or low on different days is indicated by the same capital letter, *A*, *B*, *C*, etc. **3.** Note the progress of the same highs and lows during the week. In which general direction do they travel? **4.** Between which two days did a low travel farthest? Least far? About how many miles did it travel in each case, measured from where the center is the first day to where it is the following day? **5.** As in 4, make similar observations for a high. **6.** What is the distance across the largest low *area* shown on all the maps? Across the largest high *area?* The smallest high? For convenience, consider that a low or a high area includes all the circles which curve in the

same direction around the center. **7.** Select from all the maps a well-defined circular low whose eye or center is somewhere over the Mississippi valley. From a study of the arrows denoting the direction of the wind at various points within this low, determine whether a cyclone is a straight-blowing or a rotating wind, and whether the winds blow from or toward the center. If a rotating wind, is its direction of rotation clockwise (in the direction in which the hands of a clock move around the dial) or counter-clockwise? **8.** Determine in the same way the same information in regard to a large well-defined high. **9.** About how far, on an average, does a high or a low travel from day to day?

No. 50. EXPERIMENT ——

Purpose. — To determine how the rotation of the earth affects the direction of winds.

Materials.

Method.

Conclusions. — **1.** Do the trade winds in the northern hemisphere blow from the north, the northeast, or the northwest? **2.** Do the trade winds in the southern hemisphere blow from the south, the southwest, or the southeast? **3.** From which direction do the prevailing westerlies in the northern hemisphere blow? **4.** From which direction do the prevailing westerlies in the southern hemisphere blow?

Discussion. — **1.** Name the three classes of winds, and enumerate the different important winds which come under each classification. **2.** Name the three important calm belts. **3.** Is there no motion of air whatever in these belts? Explain. **4.** Compare the movement of winds due to the heating of the earth at the tropics to the movement of air currents caused by a hot stove in a room. In

each case account for four different currents of air or winds. **5.** What is the relation between pressure and wind? **6.** Explain fully the cause of the land and sea breeze. **7.** What are the distinctions between a cyclone and a tornado?

Diagrams. — 1. Draw a circle to represent the earth, draw a line across the middle to represent the equator, and write neatly upon the circle approximately in their proper places the following: doldrums, trade winds (two belts), anti-trades (two belts), horse latitudes (two belts). Draw small arrows upon the different wind belts on the diagram, to indicate the general direction in which the winds blow in each case. **2.** Draw another circle to represent the globe, and indicate upon this circle the path of the water over its surface.

No. 51. EXPERIMENT ——

Purpose. — To learn what is meant by refraction of light.

Materials.

Method.

Conclusions. — 1. Did the coin, the black line, and the pencil point change their positions, or merely appear to do so? **2.** Did the light which came from the coin and the pencil point continue on in the same straight line, or did it bend as it entered the air from the water? **3.** Similarly, did the light from the black line continue on in the same direction, or did it bend as it left the glass? **4.** Since these are typical illustrations of refraction of light, as it passes out of one transparent substance (water and glass) into another of different density (air), define refraction of light.

Discussion. — 1. The stars shine with a steady light, but this light has to reach the earth by traveling through various air currents of different density. Explain the

twinkling of the stars. **2.** The sun appears to be just above the horizon when it really is just below it. Sunset, therefore, occurs from two to four minutes later and sunrise from two to four minutes earlier than it otherwise would. Explain. **3.** Why does the full moon when it first rises above the horizon appear oblong, like a football, instead of perfectly round? **4.** Why does an oar appear bent when in the water? **5.** Does a fish appear to be nearer or farther from the surface of the water than it really is? Explain. **6.** Why do objects viewed through ordinary window glass appear distorted?

Diagram. — Draw a neat diagram of the tumbler containing the coin and water. Draw the coin where it actually was on the bottom of the tumbler, and also, by dotted lines, where it appeared to be when the water was added. Draw a straight line from the apparent position of the coin directly over the rim of the tumbler to the eye. Label this line, " Apparent path of light from coin to eye." Draw another line from the coin directly to the point where the apparent path left the surface of the water, and from this point to the eye. Label this beam, " Actual path of light to eye." Also write the word " eye " in its proper place.

No. 52. EXPERIMENT ——

Purpose. — To learn what is meant by dispersion of light.

Materials.

Method.

Conclusions. — **1.** Since the only light which traveled through the prism was sunlight (white light), what does a prism do to sunlight? **2.** Define dispersion, considering that what the prism did to the sunlight was a typical example.

Diagram. — Draw a neat diagram of the prism showing the path of the beam of sunlight through it, getting wider the farther it goes from the prism. Write the word *vibgyor*, indicating the different colors of the spectrum, *v*iolet, *i*ndigo, *b*lue, *g*reen, *y*ellow, *o*range, *r*ed, in its proper place on the diagram, to indicate how the colors are separated by the prism. The red is bent least in passing through the prism, and the violet most.

No. 53. EXPERIMENT ——

Purpose. — To learn how *colors* may be built up from other *colors*.

Materials.

Method.

Conclusion. — Since the final color produced was due to the addition or combination of the different colors, how could sunlight be produced, theoretically?

Discussion. — **1.** To what is dispersion really due? **2.** Why was it not possible with the available apparatus to produce perfectly white light? **3.** Briefly state the cause of the rainbow. **4.** Why does the process illustrated in the experiment bring about different results from those produced when paints are mixed? **5.** Account for the fact that the spectrum produced by the prism was almost entirely uncolored in the middle, though red at one end and blue at the other. **6.** What is meant by complementary colors?

No. 54. EXPERIMENT ——

Purpose. — To determine what sort of motion a body has when it is giving off a sound, and to determine whether rigid bodies carry sounds better than yielding ones, or not so well as yielding ones.

Materials.

Method.

Conclusions. — **1.** What sort of motion has a body which is emitting sounds? **2.** Do rigid or yielding bodies carry sound best?

Discussion. — **1.** Will sound travel through a vacuum? Explain. **2.** Why is it that if two stones are tapped together under water, a person diving hears the sound much more loudly than he would if he were out of water and the stones were tapped in the same way, the same distance from him? **3.** Would a sounding body vibrate longer in air, in water, or in a vacuum? Explain. **4.** In the early days on the plains, travelers were often able to detect the presence of horses some distance away by placing their ears to the ground, when no sound could be detected through the air. Explain.

Diagram. — Make a neat diagram of a sounding tuning fork, indicating by dotted lines the positions of the prongs. Place the following terms in their correct places upon the diagram: tuning fork, prongs.

No. 55. EXPERIMENT ——

Purpose. — To determine whether a neutral body is attracted or repelled by either a plus or a minus charge.

Materials.

Method. — Write these definitions or explanations after the heading *Method* in your notebook:

A glass rod rubbed with silk has on its surface a plus (+) charge.

An ebonite or sealing wax rod rubbed with woolen cloth has on its surface a minus (−) charge.

When a *neutral* body is charged by bringing it into contact with another body which is charged either plus or minus, it assumes the *same* charge as that on the charging body. If, for instance, bits of paper *touch* a *minus* charged fountain pen, they become *minus*, but if they *touch* a *plus* charged glass rod, they become *plus* charged.

Conclusion. — Is a neutral body attracted or repelled by either a plus charged body or a minus charged body, or by both?

Diagram. — Draw the induction cylinder with both balls charged minus. Write neatly under your diagram what it represents.

No. 56. EXPERIMENT ——

Purpose. — To determine the law governing electrostatic attraction and repulsion between charged bodies.

Materials.

Method.

Conclusions. — **1.** Do like signs attract or repel each other? **2.** Do unlike signs attract or repel each other?

No. 57. EXPERIMENT ——

Purpose. — To determine whether the leaves of a charged electroscope converge or diverge farther when approached (I) by the same sign, and (II) by the opposite sign.

Materials.

Method.

Conclusions. — **1.** Do the leaves of a charged electroscope converge or diverge farther when approached by the same sign? **2.** By the opposite sign?

No. 58. EXPERIMENT ——

Purpose. — (I) To learn how to charge an electroscope by induction. (II) To determine whether an electroscope charged by induction has the same sign as, or the opposite sign to, that of the charging body.

Materials.

Method. — I. Describe fully the four steps involved in charging an electroscope by induction, telling the effect of every step upon the leaves. II. Tell all that was done with the electroscope in working out the rest of the experiment after the electroscope was charged.

Conclusions. — **1.** Was the electroscope charged plus or minus by induction from the charged rod? Justify your answer. **2.** Does a body charged by induction have the same sign as, or the opposite sign to, that of the charging body?

Diagram. — Draw the electroscope, showing how it looked after being charged by induction from the minus ebonite or sealing wax rod. Put the correct signs on the leaves, and write under your diagram a statement telling definitely what the diagram stands for.

Discussion. — **1.** What sign would be given an electroscope by charging it by contact with a glass rod previously rubbed with silk? **2.** Because a body is *attracted* by a charged body, is the body necessarily charged? Explain. **3.** Because a body is *repelled* by a charged body, is the body necessarily charged? Explain. **4.** If the pithballs of the induction cylinder are placed between a charged sealing wax rod and one's finger, they will jump back and forth between the wax and the finger. Explain. **5.** In charging the electroscope by induction, why was the finger removed before the charging rod was removed? **6.** If a person were

given an electroscope, a piece of silk, and a glass rod, how could he determine whether an unknown charge were plus or minus?

No. 59. EXPERIMENT ——

Purpose. — To determine the law governing magnetic attraction and repulsion between like and unlike magnetic poles.

Materials.

Method.

Conclusions. — **1.** Do like poles attract or repel each other? **2.** Do unlike poles attract or repel each other?

No. 60. EXPERIMENT ——

Purpose. — To study the Field of Force surrounding magnets, in order to determine the arrangement of magnetic lines of force (I) in the field surrounding a bar magnet, (II) in the field between pairs of like poles, and (III) between pairs of unlike poles.

Materials.

Method.

Conclusions. — **1.** Are the magnetic lines of force arranged in straight or in curving lines between poles? **2.** Is there any exception to this in (I), and, if so, about how far from the ends of the poles of the magnet does it occur? **3.** Do the lines of force pass directly between like poles in (II)? **4.** Do the lines of force pass directly between unlike poles in (III)?

Discussion. — **1.** Using the compass, how could one determine the polarity of a magnet hidden under a sheet

of paper? **2.** Because a nail is *attracted* by a magnet is the nail necessarily a magnet? Explain. **3.** If one end of a nail is *repelled* by a magnet, is the nail necessarily a magnet? Explain. **4.** Without using compass, magnet, or other steel or iron body, how could one determine whether a given nail were a magnet? **5.** Name some magnetic materials other than iron and steel. How do their magnetic properties compare with those of iron or steel? **6.** Does a compass needle indicate true north? Explain. **7.** Name at least two differences between magnetic and electrostatic phenomena.

Diagrams. — Draw *accurately* and neatly the fields shown in all parts of the experiment. Write *N* or *S* upon each pole of all the magnets in the diagrams to indicate the polarity, and caption the diagrams respectively as follows: (I) diagram showing the magnetic Field of Force surrounding a bar (or horseshoe) magnet; (II) diagram showing the magnetic Field of Force between pairs of like poles; (III) diagram showing the magnetic Field of Force between pairs of unlike poles.

No. 61. EXPERIMENT ——

Purpose. — To learn how a simple voltaic cell may be made, and to determine under what conditions the current flows through the circuit.

Materials.

Method.

Conclusions. — **1.** Of what different materials did this particular type of simple voltaic cell consist? **2.** Was there any electricity flowing through the wire when the circuit was broken or disconnected at some point? **3.** Was there any electricity flowing through the circuit when the circuit was unbroken or connected throughout?

Diagram. — Draw neatly the simple cell and complete circuit. Write neatly upon the diagram the following terms in their proper places: copper plus plate, zinc minus plate, connecting wire, compass, dilute H_2SO_4 (or whatever other acid was used), cell.

No. 62. EXPERIMENT ——

Purpose. — To determine the effect of sending a current from a simple voltaic cell through a coil of wire.

Materials.

Method.

Conclusion. — What is the effect of sending a direct current of electricity through a coil of wire?

No. 63. EXPERIMENT ——

Purpose. — To learn how an electric bell is constructed and to determine under what circumstances it rings and why.

Materials.

Method.

Conclusions. — **1.** What condition must exist in the circuit before the electric bell will ring? **2.** Why did the armature come over against the bell? **3.** Why did it not remain over against the bell?

Discussion. — **1.** What is the purpose of the push button at the front door? **2.** If the push button becomes stuck when pushed in, the bell continues to ring until the battery is exhausted or until the wire is broken or disconnected somewhere in the circuit. Explain. **3.** Name three electric instruments, besides the electric bell, which contain electromagnets. **4.** Diagram a system of electric bell connections, showing how a single bell and a single dry cell

may be so connected that the bell may be rung independently by push buttons at three different doors. Label your diagram with the terms: push button, bell, cell. **5.** Diagram a system of bell connections showing how two bells and a single cell may be so connected that the bells may be rung independently by push buttons at two different doors. Label your diagram: push buttons (two of them), bells (two of them), cell.

Diagram. — Draw the complete electric bell circuit used in this experiment. Write neatly upon this diagram in their proper places the following terms: cell, connecting wires, hammer, bell, electromagnet, spring, contact, armature, push button.

No. 64. EXPERIMENT ——

Purpose. — To learn how to read electric and gas meters and to learn how to compute bills from them.

Materials.

Method, Conclusions, and Discussion. — **1.** What is the greatest number of cubic feet which can be read from the gas meter? **2.** What advantage is derived from reading the gas meter to the nearest hundred feet? **3.** If the gas meter reading were 85,400 cu. ft., for March, and 87,200 cu. ft., for April, what would the bill be at $.10 per hundred cubic feet, allowing 5% discount for prompt payment? **4.** What is the greatest number of kilowatt hours which can be read from the electric meter? **5.** Compute the April electricity bill if the March and April readings were respectively 689 and 723 K. W. hr., at $.09 for each of the first ten K. W. hr., $.07 for each of the next ten, and $.05 for each of the rest, allowing a 5% discount for prompt payment. **6.** After a kettle full of food has been brought to a boil, the gas may be turned down low under the kettle,

and still the food will cook just as well, provided it is not desired to boil the food down. Explain. **7.** For what purpose is the simmerer on a gas range intended? What caution must one use in cooking with the simmerer? **8.** Explain fully how, by means of a watch and the gas meter, one may work out a table showing the gas consumption per hour of every burner on the gas range. What good would such a table be?

Diagrams. — (I) The dial face of a gas meter reading 89,200 cu. ft.; (II) the dial face of an electric meter reading 899 K. W. hr. Write above each dial the total number of cu. ft., or K. W. hr., registered by the dial in one *complete* revolution. Draw an arrow beside each dial to indicate the direction in which the hand on that dial revolves.

No. 65. **EXPERIMENT ——**

Purpose. — To determine what constitutes a *physical change.*

Materials.

Method.

Conclusions. — **1.** Did the glass and the salt lose their identity as glass and salt during the above processes? **2.** Since these are typical examples of physical change, what, therefore, must constitute a physical change?

No. 66. **EXPERIMENT ——**

Purpose. — To determine what constitutes a *chemical change.*

Materials.

Method.

Conclusions. — **1.** Did the marble and the match lose their identity as marble and wood during the above processes? Why do you think so? **2.** Since these are typical examples of chemical changes, what, therefore, must constitute a chemical change?

Discussion. — **1.** Divide the following changes into two classes, physical and chemical changes: burning of candle grease; melting of ice; exploding of gunpowder; souring of milk; crushing of rock; magnetizing of iron; rusting of iron; digestion of food; the changes which inspired breath undergoes. **2.** Give two *original* examples each of physical and chemical changes.

Diagram. — Draw a neat diagram illustrating the method by which the liquids were evaporated to dryness. Write in their proper places upon the diagram the following terms: burner, evaporating dish, stand.

No. 67. EXPERIMENT ——

Purpose. — To prepare oxygen (O) in order to determine (I) in what state of matter it ordinarily exists, (II) what its color is, and (III) its density as compared with that of water.

Materials.

Method.

Conclusions. — **1.** Is O a solid, a liquid, or a gas? **2.** What is the color of O? **3.** Is O more or less dense than water? Why do you think so?

Diagram. — Draw the apparatus and write neatly in their proper places these terms: $KClO_3$, MnO_2, delivery tube, burner, pneumatic trough, O, water, support stand.

No. 68. EXPERIMENT ——

Purpose. — To determine whether O is combustible, or a supporter of combustion.

Materials.

Method.

Conclusions. — **1.** Is O combustible? Justify your answer. **2.** Is O a supporter of combustion? Justify your answer.

Discussion. — **1.** If you were given two jars exactly alike, one full of O and the other of air, how would you determine which was which? **2.** Why does a fire burn more vigorously if it is fanned or blown upon with a bellows? **3.** Would a bellows blowing pure O upon a fire make it burn more or less vigorously than it would if air were used? Why? **4.** If the air were pure O, would the iron (Fe) of iron-framed buildings be fireproof? Explain. **5.** About what per cent of the air is O? **6.** Why not collect O in an air-filled jar, instead of a water-filled jar? **7.** Why was the picture wire coated with S before an attempt was made to make it burn in O? **8.** Name three practical benefits derived from the O in the air. **9.** What disadvantages would accrue from having the air made up wholly of O?

No. 69. EXPERIMENT ——

Purpose. — To prepare hydrogen (H) in order to determine (I) in what state of matter it ordinarily exists, (II) what its color is, and (III) whether it is more or less dense than water.

Materials.

Method.

Conclusions. — **1.** Is H under ordinary conditions a solid, a liquid, or a gas? **2.** What is its color? **3.** Is H more or less dense than water?

Diagram. — Draw the generator and show how the H was collected. Write the following terms neatly in their proper places upon the diagram: thistle tube, Zn or Fe, dilute HCl (or H_2SO_4), delivery tube, bottle, pneumatic trough, H, water.

No. 70. EXPERIMENT ——

Purpose. — To determine whether H is combustible or a supporter of combustion.

Materials.

Method.

Conclusions. — **1.** Is H combustible? Justify your answer. **2.** Is H a supporter of combustion? Justify your answer.

Discussion. — **1.** Why was there a noise when the lighted match was presented to the test tube containing the first gas collected? What was formed? What kind of change, physical or chemical, took place? **2.** Why was the lower end of the thistle tube placed beneath the surface of the liquid in the generator? **3.** Why was the cloth wrapped around the generator? **4.** A vessel may be filled with H, by putting the mouth of the delivery tube at the mouth of the *inverted* vessel filled with air. What does this indicate regarding the relative densities of H and air? **5.** Given five exactly similar jars, filled respectively with air, O, H, CO_2, and N, how could one determine which was which? **6.** What would be liable to occur if there were considerable quantities of free H in the air?

No. 71. EXPERIMENT ——

Purpose. — To determine the effect of sending a direct current of electricity through water (H_2O).

Materials.

Method.

Conclusions. — **1.** What happens when a direct current of electricity is sent through water? **2.** Of how many substances, solids, liquids, or gases, therefore, is water made up?

Diagram. — Neatly diagram the apparatus used in this experiment. Write upon the diagram in their proper places: slightly acidulated water, plus terminal, minus terminal (of the decomposing apparatus), and the names of the substances obtained from water.

No. 72. EXPERIMENT ——

Purpose. — To identify the substances obtained from the water in No. 71.

Materials.

Method.

Conclusions. — **1.** What is the greater quantity of substance obtained by decomposing or breaking up the water? Justify your answer. **2.** What is the lesser quantity of substance obtained by decomposing or breaking up the water? Justify your answer.

Discussion. — **1.** What name is given to the process of decomposing chemical substances by means of a direct current of electricity? **2.** What name would be given specifically to the decomposition of water by means of a direct current of electricity? **3.** Why was a little acid added to the water before any attempt was made to decompose it?

No. 73. EXPERIMENT ——

Purpose. — To prepare nitrogen (N) in order to determine (I) in what state of matter N ordinarily exists, (II) what its color is, and (III) whether it is more or less dense than water.

Materials.

Method.

Conclusions. — **1.** Is N under ordinary conditions a solid, a liquid, or a gas? **2.** What is the color of N? **3.** Is N more or less dense than water? Why do you think so?

Diagram. — Draw neatly the apparatus with which N was obtained. Write in their proper places the following terms: bottle or jar, N, cork (or crucible) upon which (or in which) the P was burned, water.

If you performed the alternative, write the following terms neatly in their proper places upon the diagram: $NaNO_2$ and NH_4Cl, rubber stopper, delivery tube, pneumatic trough, bottle, N.

No. 74. EXPERIMENT ——

Purpose. — To determine whether N is combustible or a supporter of combustion.

Materials.

Method.

Conclusion. — Is N combustible or a supporter of combustion? Why do you think so?

Discussion. — **1.** About what fraction of the air is N? **2.** Name two advantages derived from having so much N in the air. **3.** Given five exactly similar jars, full respectively of air, CO_2, O, H, and N, explain fully how one could determine which was which. **4.** Explain the source of the

dense white fumes of phosphorus pentoxide which immediately filled the jar when the P was ignited. What became of them? **5.** Why did the water level rise inside the jar? **6.** Name several substances other than N, which are in the air or compose it.

No. 75. EXPERIMENT ——

Purpose. — To prepare carbon dioxide (CO_2) in order to determine (I) in what state of matter it ordinarily exists, (II) what its color is, and (III) whether it is more or less dense than air.

Materials.

Method.

Conclusions. — **1.** Is CO_2 under ordinary conditions a solid, a liquid, or a gas? **2.** What is the color of CO_2? **3.** Is CO_2 more or less dense than air? Why do you think so?

Diagram. — Draw the apparatus with which CO_2 was generated, and write in their proper places the following terms: generator, thistle tube, marble chips (or calcium carbonate, clam-shells, or soda, whichever was used), hydrochloric acid (or vinegar), tumbler, glass plate, delivery tube, CO_2.

No. 76. EXPERIMENT ——

Purpose. — To determine whether CO_2 is combustible or a supporter of combustion.

Materials.

Method.

Conclusion. — Is CO_2 combustible or a supporter of combustion? Justify your answer.

No. 77. EXPERIMENT ——

Purpose. — To determine the effect (I) of carbonic acid upon limewater, and (II) of subjecting calcium carbonate ($CaCO_3$), that is, limestone or marble, to the action of strong carbonic acid. (Carbonic acid is formed whenever CO_2 comes in contact with water, since it is a chemical union of CO_2 and water.)

Materials.

Method.

Conclusions. — **1.** What happens when weak carbonic acid comes in contact with limewater? **2.** What is the effect of strong carbonic acid upon $CaCO_3$?

Discussion. — **1.** If upon blowing his breath into limewater, a person found that a white precipitate was formed (that is, that the limewater became cloudy) what gas would he conclude that his breath contains? **2.** Would CO_2 be an efficient fire extinguisher? Explain. If so, would it be more efficiently used against fires near the floor or near the ceiling? Explain. **3.** Give two reasons why blowing upon a burning match extinguishes the flame. **4.** Given five exactly similar jars filled respectively with O, CO_2, H, N, and air, how could one determine which was which? **5.** Explain how carbonic acid is formed in nature. **6.** Explain fully how limestone caves and natural bridges are formed. **7.** Soda water is charged with CO_2. Why does soda pop effervesce when the stopper of the bottle is removed? **8.** Explain fully how stalactites, stalagmites, pillars, and pilasters are formed in nature. **9.** Name some limestone formations which are deposited by the action of springs. **10.** Given a rock and some acid, how could one determine whether or not the rock contained a carbonate?

No. 78. EXPERIMENT ——

Purpose. — To learn the effect of an acid, a base, and a salt upon (insert here the name of the indicator used), in order to determine how to tell whether any given soluble substance is an acid, a base, or a salt.

Materials.

Method.

Conclusions. — **1.** What effect had the acid upon (the indicator)? **2.** What effect had the base? **3.** What effect had the salt? **4.** How, therefore, could one determine whether any given soluble substance were an acid, a base, or a salt?

No. 79. EXPERIMENT ——

Purpose. — Using the knowledge gained in the preceding experiment, to determine how much soda (base) it takes to neutralize a cup of sour milk (an acid).

Materials.

Method.

Conclusion. — How much soda was required to neutralize the cup of sour milk?

Discussion. — **1.** What is meant by a neutral solution? **2.** Why is soda often put into tomatoes which are being cooked? **3.** When the soda was added to the sour milk, what caused the effervescence? What gas was given off? **4.** Soda is added to sour milk pancakes to make them "light." Explain. **5.** Fresh berries curdle milk. Explain. **6.** What unpleasant effect might result from putting a large quantity of soda into any acid food which is being prepared? From adding too small a quantity? **7.** Poorly

drained soil is often said to be "sour." What is meant by this, and how could one determine whether the soil were "sour"? **8.** Why is acid soil unproductive? **9.** How can acidity in soil be eliminated?

No. 80. EXPERIMENT ——

Purpose. — To learn how to remove various kinds of stains from cloth.

Materials.

Method and Conclusions. — **1.** How may grease stains be removed? **2.** Grass and flower stains? **3.** Rust stains? **4.** Ink stains? **5.** Paint stains? **6.** Acid fruit stains?

Discussion. — **1.** Explain why a blotter "takes up" hot grease. **2.** Where else in this course have we used the principle illustrated in removing grass stains? **3.** What is rust? **4.** Why is it that the same method of removing ink stains is not always successful? **5.** What grave danger is always present when gasoline or benzine are used for cleaning purposes, making it *imperative* that some substitute, such as that used above, should be used? **6.** Why is ammonia successful for the removing of fruit stains? Why not use a strong alkali or base, such as sodium hydroxide?

No. 81. EXPERIMENT ——

Purpose. — To learn how to determine (I) whether milk contains formaldehyde; (II) whether canned peas or beans contain copper salts; (III) whether baking powder contains alum; (IV) whether meat contains boric acid; and (V)

whether catsup, jam, or jelly contains artificial coloring matter.

Materials.

Method.

Conclusions. — **1.** How may one determine whether milk contains formaldehyde? **2.** How may one determine whether canned vegetables contain copper salts? **3.** How may one determine whether meat contains boric acid? **4.** How may one determine whether baking powder contains alum? **5.** How may one determine whether food preparations contain artificial coloring matter?

No. 82. EXPERIMENT ——

Purpose. — Using the knowledge gained in the preceding experiment, to determine whether samples of certain commercial food preparations contain any of the above harmful adulterants.

Materials.

Method.

Conclusions. — State here the results of your experimentations, telling which samples did or did not contain the adulterants tested for.

Discussion. — **1.** What is meant by a "food adulterant"? **2.** What advantages are there to be gained from buying only goods put out by reputable firms, even though such goods cost more? **3.** Are all food adulterations harmful? Give three reasons why unscrupulous dealers adulterate foods. **4.** Why should children not be permitted to eat boiled "Easter eggs," the shells of which have been colored? **5.** When buying candy, why should one insist upon being supplied with pure candy which has been colored with fruit colorings?

No. 83. EXPERIMENT ——

Purpose. — To study some typical minerals in order to determine (insert here the list of qualities you are going to determine).

Materials.

Method and Conclusions. — (Fill in the list as instructed.)

No. 84. EXPERIMENT ——

Purpose. — To determine some of the conditions under which stalactites and stalagmites are formed, and to learn how they are formed.

Materials.

Method.

Conclusions. — **1.** In what form were the materials from which the stalactites and stalagmites formed? **2.** Why did the stalactite and stalagmite deposit?

Discussion. — **1.** What are the two conditions under which calcium carbonate stalactites are deposited? **2.** What are the three conditions essential to the perfect development of stalactites? **3.** How may the small stalactites sometimes seen beneath stone bridges, arches, and old stone buildings be accounted for? **4.** Of what substances other than calcium carbonate are stalactites sometimes formed? **5.** Why are calcite (calcium carbonate or lime carbonate) and ice stalactites seen in greatest perfection in caves? **6.** How large do calcite stalactites become? **7.** What is the estimated length of time it has taken the largest calcite stalactites to form? **8.** How are pillars and pilasters formed?

Diagram. — Draw the apparatus used in this experiment. Write neatly in their proper places upon the dia-

gram the following terms: support, gauze, siphon, stalactite, stalagmite, beaker, concentrated alum solution, paraffin plug.

No. 85. EXPERIMENT ——

Purpose. — To learn how to test for hard water, and to determine whether a given sample of water is hard or not.

Materials.

Method.

Conclusions. — **1.** How may one test for hard water? **2.** Was the given sample of water hard? Justify your answer.

Discussion. — **1.** Why is rain water often more satisfactory for laundry purposes than well water? **2.** Why are people living in cities usually less apt to be troubled with hard water than country dwellers? **3.** What chemicals produce hardness in water? **4.** State two reasons why washing clothes in hard water is apt to be unsatisfactory. **5.** What substances are apt to be most successful in eliminating hardness in water?

No. 86. EXPERIMENT ——

Purpose. — To study some typical rocks in order to determine (insert here the list of qualities you are to test for).

Materials.

Method and Conclusions. (Fill in the table as instructed.)

Discussion. — **1.** What is the distinction between a mineral, a rock, and an ore? **2.** In what three ways are metamorphic rocks formed?

No. 87. EXPERIMENT ——

Purpose. — To determine how many different kinds of substances may be found in a given sample of soil.

Materials.

Method.

Conclusions. — Name and describe the different kinds of substances which were discovered in the given sample of soil.

No. 88. EXPERIMENT ——

Purpose. — To determine which of several samples of soil permits water to sink through it most readily.

Materials.

Method.

Conclusions. — Name the different samples of soil studied, in the order in which they allow the water to sink through them.

Diagram. — Draw the apparatus and write neatly in their proper places: chalk box, test tubes, cotton, pan.

No. 89. EXPERIMENT ——

Purpose. — To determine in which of several samples of soil the capillary action is greatest.

Materials.

Method.

Conclusions. — Name in order of their capillary action the different samples of soil studied. (The water will rise highest in whichever substance has the greatest capillary action.)

Diagram. — Draw the apparatus and write neatly in their proper places upon the diagram the following terms: test tubes, sand, clay, fine gravel, loam, pan of water. Shade the test tubes to indicate the level to which the water rose in each test tube.

No. 90. **EXPERIMENT ——**

Purpose. — To determine what kinds of soil "cake" most readily, and whether working the soil while it is wet affects the caking.

Materials.

Method.

Conclusions. — **1.** Do heavy or light soils cake most readily? **2.** Does the cultivation of the different soils, while wet, affect their caking? If so, what is the effect?

No. 91. **EXPERIMENT ——**

Purpose. — To determine whether soil contains air.

Materials.

Method.

Conclusion. — Does soil contain air?

Diagram. — Draw the apparatus and write neatly in their proper places the following terms: bottle, sub-surface soil, water, air, stopper.

No. 92. **EXPERIMENT ——**

Purpose. — To determine whether fertilizing the soil pays.

Materials.

Method.

Conclusion. — Does fertilizing the soil pay?

No. 93. EXPERIMENT ——

Purpose. — To learn how soil may be kept from losing its moisture.

Materials.

Method.

Conclusions. — State two different methods by which the moisture in the soil may be conserved.

Discussion. — **1.** Why is alluvial soil fertile? **2.** Explain fully the results of No. 89. **3.** How does the plant secure the soil water? **4.** What effect has cultivating the soil upon its capillarity? Explain fully the effect of this. **5.** What is the principle upon which dry-farming is based? **6.** The fertility of soil may be increased by turning under the sod and allowing it to rot. Explain. **7.** State two ways in which earthworms help a garden. **8.** What is "fertile soil"? **9.** What is "humus"? What is its importance? How is its presence in soil indicated? **10.** What kinds of soil need artificial drainage? **11.** What connection is there between soil and the life of man? **12.** What is the value of soil study? **13.** State three advantages to be derived from rotating crops. **14.** Show how lime and limestone help to increase the fertility of a sandy soil; of a clayey soil; of a "sour" soil. **15.** How does the freezing of "heavy" soil in winter help prepare it for plant growth? **16.** If "sour" soil is "burned over," there is often a heavy growth of plants for a year or so after. Why? **17.** Name three classes of soil bacteria and state briefly what each does. **18.** Where is glacial soil found in the United States? **19.** What are the characteristics of glacial-drift soil?

No. 94. EXPERIMENT ——

Purpose. — To make a contour map in order to learn what is meant by contour line, and contour interval.

Materials.

Method.

Conclusions. — **1.** What is the relation between the points on a contour line, and vertical height above sea level? **2.** What is meant by contour interval?

No. 95. EXPERIMENT ——

Purpose. — To study a topographical map in order to learn how to interpret the conventional symbols.

Materials.

Method, Conclusions, and Discussion. — **1.** What is a topographical map intended to show? **2.** What is the contour interval of the map? What is the scale of the map? Explain what is meant by each. **3.** What is the nature of the area where the contour lines are close together? **4.** What is the nature of the area where the contour lines are far apart? **5.** Why are some of the contour lines heavier than others? **6.** As a rule, do roads tend to follow along contour lines or to take the shortest path across them? Why? **7.** Find a road where the contour lines are close together; note that where the road crosses the contour line, the latter bends more or less sharply. Does the road ascend or descend toward these bends? **8.** When a contour line crosses a stream, does the bend of the contour line point upstream or downstream? **9.** If there is a river island on the map, does the more pointed end of the island usually point upstream or downstream? **10.** Do more or fewer contour lines cross the moun-

tain streams than the valley streams? Why? **11.** What do the colors blue, green, white, and brown indicate on the map? **12.** How can one tell a hill from a ridge on the map? **13.** How are scattered houses indicated on the map? **14.** In what color, for the most part, are man-made features printed? **15.** Name three practical uses of a contour map such as this one.

Diagrams. — **1.** Make a sketch contour map to illustrate a young stream valley. Draw both a longitudinal and a cross profile of the valley represented thus, at a point near the lower end. Indicate by dotted lines how a mature valley would differ from this, both in longitudinal and cross profile. **2.** Make a sketch profile of an elongated hill a little over 50 ft. high, having a steep slope on one side, and on the other side a gradual slope cut by a gorge, extending nearly to the top. Make a profile across the hill the longest way. Contour interval, 10 ft.

No. 96. EXPERIMENT ——

Purpose. — To note a few of the facts obvious from a study of the Crater Lake Topographical Sheet, Oregon.

Method, Conclusions, and Discussion. — **1.** What indication is there on the sheet to prove that Wizard Island was itself formerly an active volcano? **2.** How does the map indicate that there is a fringe of lava extending along the lake floor from the base of Wizard Island? **3.** Note the lake soundings and tell the location of the two other cinder cones which lie beneath the lake surface. **4.** How much higher than Dutton Cliff is the highest point on the Crater Lake rampart? **5.** What do you infer that the Phantom Ship is? **6.** The Devil's Backbone is an andesite dike. How are dikes formed? **7.** How may one know

from the map that there are no real beaches along the margin of the lake? **8.** Why should there be more of a beach on Wizard Island than anywhere along the margin of Crater Lake? **9.** In what two ways may calderas be caused? By which was Crater Lake caused? **10.** State several reasons why Crater Lake may justly be termed one of the world's natural wonders.

Diagram. — Make a profile in a direct line from Glacier Peak over the top of Wizard Island to a point on the 8000-foot contour line near Dutton Cliff. Use the same horizontal scale as that on the sheet, and let each centimeter of vertical scale represent 250 ft. This is only for the topography of the rim and of Wizard Island, and is not intended to represent a profile of the bottom of the lake from the soundings. Below the profile, indicate the horizontal scale in miles. Write along the margin beside the profile the elevations represented by each centimeter rise, and write neatly in their proper places: lake level, Wizard Island, Crater (on Wizard Island), Glacier Peak.

No. 97. EXPERIMENT ——

Purpose. — To deduce some facts which are suggested by the study of a dormant (or young extinct) volcano.

Materials. — Shasta Special Topographical Map, California.

Method, Conclusions, and Discussion. — **1.** In what part of California is the region represented on the sheet? **2.** What indications are there that Shasta has been dormant for many years? **3.** Lassen, just south of Shasta, has recently erupted, after a long dormant period. Vesuvius once remained dormant for nearly five hundred years. Why, therefore, should Shasta be termed dormant rather

than extinct? **4.** How may the presence of Shastina be accounted for? **5.** How may the numerous cinder cones near Shasta be accounted for? **6.** What are the characteristics of Shasta, as shown on the topographic map, which prove that it is a young, inactive volcano? **7.** Which is younger, Shastina or Shasta? Justify your answer. **8.** What does the broad, irregular base of Shasta indicate with respect to the kind of eruptions the mountain must have had? **9.** What evidences are there that all the eruptions of Shasta and in the near vicinity were not of the same kind? **10.** Account for the fact that Panther Creek is intermittent over the lower part of its course, as indicated on the sheet. **11.** Account for the fact that Squaw Creek is clear while Mud Creek, near by, is muddy and turbulent. **12.** Why are most of the streams on the eastern or northeastern side? **13.** What does the steepness of the cliffs around which the glaciers flow indicate as to the amount of glacial weathering and erosion?

Diagram. — Draw a profile from the highest fork of Mud Creek to the summit of Shasta, and down the other side in the same straight line until it meets Whitney Glacier. Use the same horizontal scale as that on the sheet, and let 2 cm. indicate a 1000-foot rise in elevation. Write neatly along the margin of the profile the elevations, and write in their proper places: summit, its elevation, Whitney Glacier, its elevation at the point where the profile reaches it, Upper Fork of Mud Creek. Indicate below the profile the horizontal distance in miles. Your profile will of course be out of proportion, because you are exaggerating the vertical scale about three times, in comparison with the horizontal.

No. 98. EXPERIMENT ——

Purpose. — To note a few of the facts suggested by a study of the topographical map of a glacial region.

Materials. — Boothbay, Maine, Topographical Map.

Method, Conclusions, and Discussion. — **1.** In what part of Maine is the region shown on the sheet? **2.** Judging from the trend of the hills and valleys, in what direction do you infer that the glacier moved? **3.** Give two indications that this region is glacial, other than the one suggested in Question 2, above. **4.** Name and locate the three centers of accumulation of the great ice-sheet which once covered the northern part of North America, and from which the glaciers moved. **5.** From which of these centers of accumulation came the glacier which once swept the Boothbay region? **6.** Noting the many indentations, the numerous islands, and the fact that the main islands are obviously an extension of the ridges on the mainland, do you conclude that this is a rising coast or a sinking coast? **7.** About how far above the water level on Southport would be the only habitation indicated, which would remain above water if the area were to sink another hundred feet? **8.** How many lighthouses are there shown on the sheet? What does the necessity for so many of them indicate with reference to the industries of the people of this region? **9.** How are the locations of the centers of population on this sheet an indication of the industries of the people? **10.** How is the commerce of this region carried on, for the most part? **11.** The physical geography of New England resembles parts of what European countries?

No. 99. EXPERIMENT ——

Purpose. — To note a few of the facts suggested by a study of the topographical map of a low sandy coastal plain.

Materials. — Atlantic City Topographical Map.

Method, Conclusions, and Discussion. — **1.** In what part of New Jersey is this region? **2.** How are off-shore bars formed? **3.** Why are the northern ends of the off-shore bars hooked toward the mainland? **4.** How may the hook on the southern extremity of Brigantine Beach be accounted for? **5.** Why are New Inlet, Absecon Inlet, and Brigantine Inlet kept open? **6.** Explain fully how such an ocean border as this one may be accounted for. **7.** What will probably be the next stage in the history of this region? **8.** How much of the land upon which Atlantic City is built would remain above water, if this region should sink 15 ft.? **9.** How much of the beaches would remain above the water, if they should sink 25 ft.? **10.** How many life-saving stations are there on the map, and how many lighthouses? Why should there be so many of the one and so few of the other? **11.** How many railroads are there connecting Atlantic City with the mainland? Why are there so many? **12.** What are the industries of this region?

No. 100. EXPERIMENT ——

Purpose. — To note a few of the facts suggested by a study of a topographical map of a portion of an old river.

Materials. — Donaldsonville, La., Topographical Sheet.

Method, Conclusions, and Discussion. — **1.** Is the area, represented by this map, flat or hilly? **2.** Where on the map is the elevation greatest? Why? **3.** For the most

part, the swamps are how far above sea level? **4.** In 1890, the levee broke at Nita Crevasse. Why did the break occur here instead of just across the river? What became of the sediment from this break? **5.** The river has built up natural levees, upon which have been superimposed higher, artificial levees. Under what circumstances, and how, are natural levees formed? **6.** Name three small rivers and bayous found on this sheet. Do they flow toward, or away from the Mississippi River? Why? **7.** Ditches are represented by the straight blue lines. Why were so many of them dug here? **8.** About how far is it, in an air line, from Hester to Port Barrow? About how far, along the river? Measure on the map with a string or thread. **9.** Bayou Lafourche, bisecting Donaldsonville, is one of the chief distributaries of the Mississippi delta. What is a delta? How formed? What are distributaries? How formed? **10.** Name four characteristics of the Mississippi, as shown on the sheet, which prove that the Mississippi at this point is an old river. **11.** Name three other characteristics of old rivers, not indicated on this sheet. **12.** Considering how scanty the population of this district is, except along the immediate banks of the Mississippi, what, probably, is the purpose of the frequent short roads from the swamp margin to the two main roads along the levees? **13.** Why is such a location as the one shown on the sheet apt to be unhealthful? **14.** How do you account for the great number of French names on this sheet?

Diagram. — Make a profile from the 5-foot contour line southwest of the river, passing between the words " Brilliant " and " Point " across the river at Nita Crevasse, and so on to the 5-foot contour line on the north bank.

Since the river level and depth are not indicated on the sheet, leave blank the part of the profile representing the river. Below the profile indicate the horizontal scale in miles.

No. 101. EXPERIMENT ——

Purpose. — To note a few of the facts suggested by a study of the topographical map of an irrigated district.

Materials. — Lamar, Colorado, Topographical Sheet.

Method, Conclusions, and Discussion. — **1.** In what part of Colorado is Lamar? **2.** Note the large number of streams shown on the map. What is the nature of all of them except the Arkansas River? **3.** What is true of practically all the lakes on the map? **4.** This part of the country receives between ten and twenty inches of rainfall annually. What, therefore, is the purpose of the canals (blue lines), which are on both sides of the Arkansas River? **5.** Which is at the greater altitude, the Arkansas Valley Canal or the Colorado and Arkansas Canal? Why the difference in altitude? **6.** Why are the canals on the southern bank of the Arkansas River at this point so much less crooked than those on the northern bank? **7.** In which is the swifter current, the Arkansas River or the canals? Why? **8.** How may the presence of so many lakes of the type seen on this map be accounted for, with respect to the nature of the country? **9.** What is the prevailing industry of the section indicated on the sheet?

Diagram. — Make a profile of the land along the eastern edge of the sheet from the 3600-foot contour line just south of the Arkansas River to the 3775-foot contour line just north of the Arkansas Valley Canal. Take the same horizontal scale as that shown on the map, and let the vertical scale be 1 cm. per 25 ft. Indicate neatly upon the profile, at the proper points, the three canals and the Arkansas River; also indicate below the profile the horizontal distance represented by the profile.

No. 102. EXPERIMENT ——

Purpose. — To determine what change in the volume of water is produced by freezing.

Materials.

Method.

Conclusion. — What change is produced in the volume of water by freezing?

Diagrams. — Draw the apparatus as it looked before and after freezing the contents. Write neatly in their proper places upon the figures the following terms: water, ice, test tube, cork.

No. 103. EXPERIMENT ——

Purpose. — To determine one way in which a river erodes and denudes land areas through which it flows.

Materials.

Method.

Conclusion. — In what way, illustrated by this experiment, does a river erode and denude the land area through which it flows?

Diagram. — Draw the apparatus, showing the *results* of the experiment. Write neatly upon the diagram in their proper places the following terms: jar, river water, sediment.

No. 104. EXPERIMENT ——

Purpose. — To determine how water, without current, stratifies soil.

Materials.

Method.

Conclusions. — **1.** When deposits are made by still water, as when the river current becomes checked, where

are the largest, heaviest particles deposited? **2.** Where are the finest particles deposited?

Diagram. — Draw the apparatus, showing the *results* of the experiment. Write neatly upon the diagram in their proper places the following terms: jar, coarsest particles, finer particles, finest particles, water.

Discussion. — **1.** Explain clearly the distinction between weathering, erosion, denudation, and deposition. **2.** How are cliffs sometimes weathered by frost? **3.** Name the various agents of weathering, and tell how weathering is effected by each. **4.** Define corrasion and corrosion. **5.** Enumerate at least five results of weathering. **6.** Name the various agents of erosion. **7.** Name the various agents of denudation. **8.** Name the various agents of deposition. **9.** Explain fully how deltas are formed. **10.** Why are deltas formed more frequently in lakes than in the ocean? **11.** How are alluvial fans formed? **12.** Give three reasons why alluvial fans are favorable to agriculture. **13.** When a swift stream bearing a great quantity of sediment strikes quiet water, where are the larger particles deposited? The smaller particles? Why, in each case? **14.** Why is a flood plain fertile?

Diagram. — Draw the apparatus, showing the results of the experiment. Write neatly in their proper places the following terms: jar, coarsest particles, finer particles, finest particles, water.

No. 105. EXPERIMENT ——

Purpose. — To determine whether the cotyledons are essential to a freshly sprouted seed.

Materials.

Method.

Conclusion. — Are the cotyledons necessary to the continued growth of a freshly sprouted seed?

Discussion. — **1.** Explain fully why the conclusion above is true. **2.** What is meant by the terms, monocotyledon and dicotyledon? In which class are the pea, the bean, and the corn? **3.** What is meant by underground cotyledons? Aboveground cotyledons? Give an example of each class. **4.** In the plants studied in this experiment, which were the primary and which the secondary roots? **5.** What constitutes the food of a young plant? **6.** Compare the histories of pea, bean, and squash cotyledons.

Diagram. — Draw neatly the device used in working out this experiment. Write neatly in their proper places upon the diagram the following terms: bottle, cheesecloth, seedling with cotyledons, seedling deprived of cotyledons.

No. 106. EXPERIMENT ——

Purpose. — To determine whether a constant supply of fresh air is essential to germination.

Materials.

Method.

Conclusion. — Is a constant supply of fresh air essential to germination?

No. 107. EXPERIMENT ——

Purpose. — To determine what substance is formed during the process of seed germination.

Materials.

Method.

Conclusion. — What is the substance evolved during the process of seed germination?

Discussion. — **1.** Considering the conclusions of this experiment and the preceding one carefully, explain fully why the conclusion of the former is true. **2.** Aside from destroying the soil capillaries and therefore preventing the evaporation of moisture from the soil, explain why frequent stirring of the soil assists germination. **3.** How does the earthworm render a similar service to agriculture? **4.** What other service does the earthworm render the agriculturist? **5.** What physiological function of animals is identical with that of the germinating seeds studied in these two experiments?

Diagrams. — Draw neat diagrams of the two bottles. Write neatly in their proper places on the diagrams the following terms: stoppered bottle, unstoppered bottle, air, peas or beans. Write also, where it belongs, the name of the substance found to have been evolved during the process of seed germination.

No. 108. EXPERIMENT ——

Purpose. — To determine the effect of a solution containing iodine upon cooked starch.

Materials.

Method.

Conclusion. — What effect has a solution containing iodine upon cooked starch?

No. 109. EXPERIMENT ——

Purpose. — To determine whether the green leaves of a plant contain starch, and if so, to determine whether there is any relation between the amount of starch in the leaf and the amount of sunlight the leaf has received.

Materials.

Method.

Conclusions. — **1.** Do the green leaves of a plant contain starch? **2.** Is there any relation between the amount of starch in a leaf and the amount of sunlight the leaf has received?

Discussion. — **1.** Does the leaf of a plant contain more starch in the early morning or late afternoon? How do you account for this? **2.** What furnishes the energy which enables the plant to manufacture starch? **3.** What is the importance of the green coloring matter (chlorophyll) of plants? **4.** From what does the plant make its starch? **5.** What becomes of the starch which is manufactured by the plant? **6.** What is the distinction between dependent and independent plants? **7.** Define photosynthesis. **8.** The process of photosynthesis may be compared to a factory. Tell what part of the process of the plant corresponds to each of the following parts of a factory: the factory itself; the machinery; the energy which runs the factory; the raw materials of the factory; the finished product of the factory; the waste product of the factory. **9.** How could one tell whether a bean, pea, or kernel of corn contains starch? **10.** Why was the chlorophyll removed from the leaf? **11.** Why is photosynthesis of importance to animals? **12.** How may one remove grass stains from clothing?

No. 110. EXPERIMENT ——

Purpose. — To determine (I) the effect of starch upon a solution containing iodine, (II) the effect of grape sugar upon Fehling's solution, (III) the effect of nitric acid and ammonia upon a solution containing protein, and (IV) of fat upon paper.

Materials.

Method.

Conclusions. — **1.** How could one determine whether a certain food contained starch? **2.** How could one determine whether a certain food contained grape sugar? **3.** How could one determine whether a certain food contained protein? **4.** How could one determine whether a certain substance contained fat?

No. 111. EXPERIMENT ——

Purpose. — Using the knowledge gained in No. 110, to determine whether certain foods contain starch, grape sugar, protein, and fat.

Materials.

Method.

Conclusions. — Make a table of the foods tested, giving first the name of the food, and then the names of the different kinds of food substances found to be contained in each.

Discussion. — **1.** Define food. **2.** Name the three food principles. **3.** Why are minerals and water not classed as food principles? What is the use of mineral matter in food? **4.** Name four different kinds of organs in which food is stored in different plants. **5.** Aside from their use as food, name one or two other uses of carbohydrates. **6.** What are the scientific reasons upon which the following food combinations are based: bread and butter; pork and beans; crackers and cheese? **7.** Why should people not eat too heavy a meat diet? **8.** Why is milk such good food? Is skim milk as good food as cream? **9.** Why does one require less fat in summer than in winter? **10.** What two factors determine the amount of food to be consumed by an animal or plant? **11.** Give three reasons for thoroughly cooking meat. **12.** What advantage is gained from cooking vegetables?

No. 112. EXPERIMENT ——

Purpose. — To examine a typical plant cell in order to learn the appearance of the nucleus, nucleolus, etc.

Materials.

Method.

Conclusions. — **1.** What were the general shapes of the cell, nucleus, and nucleolus? **2.** What were the relative sizes of the nucleus and nucleolus? **3.** What were the relative positions, with respect to each other, of the cell, the nucleus, and the nucleolus?

Discussion. — **1.** What is the relation between plant and animal cells, and plant and animal tissue? **2.** About how large are cells? **3.** In what sense is the cell the working unit and the unit of structure of a plant or animal? **4.** Explain in terms of cell reproduction how plant and animal tissues grow.

Diagram. — Make a neat diagram, showing as well as you can the shape of the cell you studied. Write neatly upon the diagram in their proper places the following terms: nucleus, nucleolus, cytoplasm, cell-wall, cell.

No. 113. EXPERIMENT ——

Purpose. — To determine, from a study of some common leaves, the form, appearance, and peculiarities of the primary parts of a leaf; namely, the petiole, the blade, and the stipules.

Materials.

Method, Conclusions, and Discussion. — **1.** Describe the blade of any of the leaves, specifying the leaf. **2.** Describe the petiole of any of the leaves, specifying the leaf. **3.** Describe the stipules of any leaf, specifying the leaf. **4.** Which leaves, if any, have no petiole? **5.** Name the

leaves you are studying which have stipules. **6.** Name two functions of the petiole. **7.** Name two functions of the blade. **8.** What is meant by a compound leaf? **9.** Are any of the leaves you are studying compound? **10.** What is meant by pinnate veining? Give an example of pinnate leaf, from those you are studying. **11.** What is meant by palmate veining? Give an example of palmate leaf from those you are studying. **12.** What is meant by parallel veining? Give an example of parallel-veined leaf from those you are studying. **13.** Whether a plant is monocotyledonous or dicotyledonous can usually be determined by the leaf veining. Which veining indicates monocotyledonous, and which, dicotyledonous plants? **14.** Name at least three modifications which leaves have developed as a protection against animals. **15.** Name three modifications of leaves which certain desert plants have undergone to prevent excessive transpiration. **16.** Give several examples of carnivorous plants. Do any of these catch their prey by means of specially modified leaves? **17.** Why have such plants developed the ability to catch living prey?

Diagram. — From the leaves studied, select one to illustrate each type of veining. Draw the leaves selected, writing in their proper places the following terms: petiole, stipules, blade. Also write under each diagram the name of the plant from which the leaf was taken, and the type of veining it illustrates.

No. 114. EXPERIMENT ——

Purpose. — To determine whether a liquid, or a substance in solution, travels through a permeable membrane to a point where that particular substance is more or less concentrated; that is, to determine whether osmosis tends to

equalize or to increase the concentration of any given liquid or substance in solution.

Materials.

Method.

Conclusions. — **1.** Did the water travel toward a point of greater or less concentration of water? **2.** Did the sirup travel toward a point of greater or less concentration of sirup? **3.** Does osmosis, therefore, tend to equalize or to increase the concentration of a liquid or a substance in solution?

Discussion. — **1.** Explain fully in the light of this experiment how and why minerals get from the soil into plant roots. **2.** How do solutions pass from cell to cell in plants? In animals? **3.** In the light of the above conclusions, why will putting salt on grass kill the grass? **4.** Explain in the light of osmosis how blood receives oxygen from, and gives up carbon dioxide to, the lungs and gills, and how the body receives nourishment from the alimentary canal. **5.** To what other process, by which substances become intermingled, is osmosis closely allied?

Diagram. — Draw neatly the apparatus used to show osmosis. Write in their proper places on the diagram the following terms: glass tube, unbroken membrane, tumbler or beaker, water, sirup.

No. 115. EXPERIMENT ——

Purpose. — To determine whether water is given off from the leaves of a plant.

Materials.

Method.

Conclusions. — **1.** Is water evaporated from the leaves of a plant? **2.** What evidence was there to prove this?

Discussion. — **1.** What is meant by transpiration? By transpiration pressure? **2.** Why do wheat and corn sometimes wilt on very hot days? **3.** Corn leaves frequently roll into rather tight tubes, on very hot days. Why? **4.** Young shade trees and orchard trees should have their branches well pruned when set out. Why? **5.** Why should garden plants and newly transplanted trees be well watered until their root systems are well formed? **6.** Why should the top of the ground be kept pulverized (well cultivated)? **7.** What three functions are fulfilled by the water which is continually entering plant roots? **8.** Why is so large a fraction of the water which enters a plant evaporated? **9.** Why do many varieties of cactus have glazed surfaces on stems and leaves, and small spines, instead of soft, broad, fleshy leaves? **10.** From which side of the leaves, the upper or the lower, is more water usually transpired? Through what organs principally?

Diagram. — Draw a neat diagram of the Potometer, used above, and write neatly in their proper places upon the diagram the following terms: plant, rubber stopper, glass tube, bubble, tumbler, bottle, water.

No. 116. EXPERIMENT ——

Purpose. — To determine whether growing plants give off oxygen (O).

Materials.

Method.

Conclusion. — Do growing plants give off oxygen?

Diagram. — Draw neatly the apparatus used, and write in their proper places upon the diagram the following terms: funnel, test tube, green water-plants, water, O (if any is given off by the plant), battery jar.

No. 117. EXPERIMENT ——

Purpose. — To determine whether growing plants give off carbon dioxide (CO_2).

Materials.

Method.

Conclusion. — Do growing plants give off CO_2?

Diagram. — Draw the apparatus used in this experiment, and write in their proper places the following terms: covered jar, uncovered jar, plant, limewater, air, carbon dioxide (if any was found to be present), soil.

Discussion. — **1.** How do water-plants secure air for their use? **2.** Account in two ways for the evolution of gas in No. 116. **3.** How do water-plants and fishes mutually assist each other in getting gases necessary for their existence? **4.** Do plants make use of none of the O which they take in? Explain. **5.** What substances are given off as waste material from plants? **6.** Would the results of No. 116 have been different, had the experiment been performed in darkness instead of bright sunlight? **7.** Through what organs does a plant secure O? **8.** In what process is CO_2 used by the plant? **9.** What indispensable service do green plants render animals?

No. 118. EXPERIMENT ——

Purpose. — To learn the principal parts of a complete flower, and where each is located in the flower.

Materials.

Method.

Conclusions. — **1.** What are the principal parts of the complete flower? **2.** Where is each located in the flower you studied?

Discussion. — **1.** For what purpose does the plant have flowers? **2.** Name five different steps in plant reproduction. Briefly tell what each step is and how it is brought about. **3.** Why is the pistil in the middle of the flower? **4.** What in the plant corresponds to a bird's egg? **5.** What is the distinction between a complete and a perfect flower? **6.** What is meant by the term, hermaphroditic plant? Monœcious plant? Diœcious plant? Give examples of each. **7.** Name three non-flowering or flowerless plants. **8.** What in these corresponds to the seed of flowering plants? **9.** What is meant by a composite flower? Give examples of composite flowers.

Diagram. — Neatly diagram the flower you studied, as it would look from the side, were you to cut it exactly in half. Write neatly in their proper places upon the diagram the following terms: ovary, sepal, petal, stigma, style, anther, receptacle, pedicel, filament. Draw braces to include the whole of the stamen and label it; do likewise for the whole pistil.

No. 119. EXPERIMENT ——

Purpose. — To study the bean embryo in order to learn what the different parts are, and where the different parts are located within the seed coat.

Materials.

Method.

Conclusions. — **1.** Describe the cotyledons or seed leaves. **2.** Where is the hypocotyl or first stem of the bean located? **3.** Describe it. **4.** Where is the plumule or first bud of the bean located? **5.** Of what does it consist? **6.** From what part of the embryo does the root grow?

Discussion. — **1.** To what great division of seed plants does the bean belong? **2.** What is the other division

of seed plants? **3.** How does the veining of the leaf indicate to which of the two divisions of seed plants a plant belongs? **4.** What are the principal plant foods found in the seed? **5.** What is the function of the seed coat? **6.** What is the function of the "soft eye" in the cocoanut? **7.** What are the three requisites for germination?

Diagram. — Draw the opened bean seed with all the different parts of the embryo as they appear. Write neatly in their proper places the following terms: cotyledon (two of them), plumule, hypocotyl, tip from which root develops.

No. 120. EXPERIMENT ——

Purpose. — To determine where the spores (the bodies from which the new plant springs) of a gilled mushroom and a puffball are located, and to determine how the spores are sown.

Materials.

Method.

Conclusions. — **1.** Where are the reproducing cells, *i.e.* the spores, of the gilled mushroom located? **2.** Where are the spores of the puffball located? **3.** In each case how are the spores sown?

Discussion. — **1.** What is the distinction between a toadstool and a mushroom? **2.** Are all mushrooms edible? **3.** Is any mushroom deadly poisonous? **4.** By what common tests can one determine whether a mushroom is edible or not? **5.** Are all mushrooms, aside from the puffball, gilled? **6.** At what seasons of the year are mushrooms obtainable? **7.** Where may one look for mushrooms? **8.** State at least three precautions to be followed in gathering mushrooms for the table. **9.** Is the edible mushroom really a good food? **10.** Where

can reliable information regarding mushrooms be obtained? **11.** To what subdivision of non-flowering plants does the mushroom belong? **12.** Name three other non-flowering plants besides the mushroom.

No. 121. EXPERIMENT ——

Purpose. — To determine what products are formed when a sugar solution is fermented by the action of yeast.

Materials.

Method.

Conclusions. — What two products were formed as a result of the fermentation? Explain how you were able to distinguish each of these products.

Discussion. — **1.** In what three states do yeasts exist? **2.** What is meant by "wild yeast"? **3.** How is fermentation of cider and fruit juices started? **4.** Where do wild yeasts, which float in the air, live and grow? **5.** What food material is required by all common species of yeasts? **6.** Why are very sweet preserves safe from fermentation? **7.** Name a practical use of yeast plants in the home.

Diagram. — Draw the apparatus used, and write neatly in their proper places the following terms: water, molasses, and yeast; flasks or test tubes; delivery tube; alcohol; limewater; carbon dioxide.

No. 122. EXPERIMENT ——

Purpose. — To determine the conditions under which molds develop best.

Materials.

Method.

Conclusions. — **1.** Do molds grow more readily on moist or dry substances? **2.** Do molds grow more readily at a high, a low, or a medium temperature? **3.** Do molds grow more readily in sunlight or darkness? **4.** Do molds grow more readily in still or moving air?

Discussion. — **1.** Is "molds" a proper scientific division of plants? **2.** Name several different divisions of non-flowering plants. **3.** What is mildew? **4.** How do culture media such as foods, fruits, leather, etc., become infected with molds? **5.** Why should sound fruits be removed from the vicinity of decayed ones? **6.** What is the value of wiping fruit frequently with a dry cloth? **7.** Name some important benefits derived from the growth of molds. **8.** Name two diseases caused by molds. How may they be transmitted from person to person? **9.** If food of all kinds quickly becomes moldy in a pantry, how can one rid the pantry of mold? **10.** State four results of mold action upon food. **11.** How may the housewife check the growth of mold upon preserved fruits? **12.** Give four practical suggestions regarding how to avoid the growth of molds upon foods in general.

No. 123. EXPERIMENT ——

Purpose. — To learn how bacterial colonies develop.

Materials.

Method.

Conclusions. — **1.** Where upon the culture medium did the colonies develop? **2.** What was the appearance of the colonies?

Discussion. — **1.** How do bacteria compare in size with molds and yeasts? **2.** Why are bacteria more troublesome than molds? **3.** Are bacteria generally considered to be animals or plants? **4.** How are bacteria classified

with regard to shape? **5.** How do bacteria reproduce? **6.** Do all bacteria require air? **7.** Where are bacteria to be found? **8.** What constitutes the food of bacteria? **9.** Name the conditions under which bacteria thrive best? **10.** How may our homes be best safeguarded from bacteria? **11.** Name several food preservatives which are not harmful and name several others which are. **12.** How do we take germ diseases? Name the most serious disease at the present time. **13.** Name several kinds of bacteria which are beneficial or indispensable to man. **14.** How do molds and bacteria supplement each other as agents of decay?

No. 124. EXPERIMENT ——

Purpose. — To determine how sunlight influences the direction of growth of a plant.

Materials.

Method.

Conclusion. — How does sunlight influence the direction of growth of a plant?

Discussion. — **1.** Why do plants grow as indicated in this experiment? **2.** Define photosynthesis. **3.** Why should ornamental house plants be turned around often?

Diagram. — Neatly diagram the plant, indicating its direction of growth relative to the direction from which the sunlight comes. Write " plant " and " sunlight " in their proper places upon the diagram.

No. 125. EXPERIMENT ——

Purpose. — To germinate seeds in order to determine the effect of gravity upon the direction of root growth.

Materials.

Method.

Conclusion. — In what direction do the roots grow in every case?

Discussion. — What two factors, other than gravity, influence the direction of the growth of roots?

Diagrams. — Draw the "pocket garden," showing the development of the roots from the germinating seeds, one drawing for each position of the garden, *i.e.* on its end and on its side. Write upon each diagram in the proper place: seed, root, bottom, and X.

No. 126. EXPERIMENT ——

Purpose. — To examine a drop of straw culture in order to form a correct idea regarding the form, movement, etc., of tiny one-celled animals.

Materials.

Method.

Conclusions. — **1.** How many different kinds of one-celled animals did you see? **2.** Did they move rapidly or slowly? **3.** Did all have relatively about the same speed of movement?

Discussion. — **1.** What do protozoa eat? **2.** State different ways in which different species obtain their food. **3.** Name several diseases supposed to be caused by protozoa. **4.** Name several places where protozoa live and are found. **5.** Are all protozoa harmful?

No. 127. EXPERIMENT ——

Purpose. — To learn how muscles are constructed and to learn to what muscles are usually attached, and by what they are attached.

Materials.

Method.

Conclusions. — **1.** Of what are muscles composed? **2.** To what are muscles like the one studied attached? **3.** By what are such muscles attached?

Discussion. — **1.** About how many separate muscles are there in the body? **2.** How does the shape of a muscle change in moving a bone? What is the reason for this change? **3.** How does the work which can be done by muscles vary with respect to the length and thickness of the muscle? **4.** Whence does a contracting muscle derive its energy? **5.** What are antagonistic muscles? **6.** What is meant by voluntary and involuntary muscles? **7.** State several reasons why much outdoor exercise is necessary. **8.** Why is violent exercise just after a heavy meal injurious? **9.** Why are games valuable as training for everyday life? **10.** Why does systematic drill in the gymnasium furnish more beneficial exercise than mere games?

No. 128. EXPERIMENT ——

Purpose. — To study two different kinds of joints found in animals in order to determine what each is for.

Materials.

Method.

Conclusions. — **1.** Which kind of joint, a ball-and-socket or a hinge, is intended to accommodate merely a swinging, back and forth movement? **2.** Which kind is intended to accommodate a rotating movement?

No. 129. EXPERIMENT ——

Purpose. — To learn what the different parts of a bone are, and where each is located in the bone.

Materials.

Method.

Conclusions. — **1.** Where is the periosteum of the bone located? **2.** The marrow? **3.** The ligaments? **4.** The hard bone? **5.** The spongy bone?

Diagram. — Draw as well as you can the cut joint of bone, and write neatly in their proper places upon the diagram the following terms: periosteum, ligament, marrow, hard bone, spongy bone.

No. 130. EXPERIMENT ——

Purpose. — To determine what characteristics a bone possesses after the mineral matter has been removed.

Materials.

Method.

Conclusion. — Does the animal matter which is in the bones render them pliable or brittle?

No. 131. EXPERIMENT ——

Purpose. — To determine what characteristics a bone possesses after the animal matter has been removed.

Materials.

Method.

Conclusion. — Does the mineral matter which is in the bones render them pliable or brittle?

Discussion. — **1.** Name two hinge joints and two ball-and-socket joints. **2.** Name two kinds of joints other than the hinge and the ball-and-socket and give an example of each. **3.** Of what kinds of inorganic matter, for the most part, are bones composed? **4.** Good thick soup may be made from well picked bones if they are boiled under pressure in a Papin's digester. Explain. **5.** Why was

there effervescence when the bone was placed in dilute hydrochloric acid? **6.** Why should milk constitute a large part of a child's diet? **7.** Why should not young children be encouraged to walk beyond their strength, — also, what frequently causes bowlegs in children? **8.** Why should not an injury to a joint be neglected? **9.** What connection is there between red blood corpuscles and red marrow?

No. 132. EXPERIMENT ——

Purpose. — To study the development of the chicken embryo, in order to determine the different stages of development.

Materials.

Method.

Conclusions. — Name as many distinct stages as you can in the development of the chicken from egg to adult. State the day upon which each change was evident, numbering as 1 the day upon which the incubation began.

Discussion. — **1.** What is the function of the white of the egg? **2.** What is the function of the yolk? **3.** How do plant seeds, such as the bean and the pea, correspond to the chicken egg? **4.** Why does the hen sit on the eggs? **5.** Aside from sitting upon the eggs, what special care does the hen take of the eggs during incubation? **6.** Why is the eggshell porous?

No. 133. EXPERIMENT ——

Purpose. — To study the development of the frog embryo, in order to determine the different stages of development.

Materials.

Method.

Conclusions. — Name as many distinct stages as you can in the development of the frog from egg to adult. State the approximate time elapsing between changes.

Discussion. — **1.** What is the function of the gelatinous mass which surrounds the eggs? **2.** Why is it necessary for the preservation of the species, that a frog should lay so many more eggs than a hen? **3.** Name some enemies of the frog. **4.** How have the frog and toad species adapted themselves, so as to preserve the species? **5.** Name some other animals closely related to the frog. **6.** Where does the embryo get its food before it is hatched? **7.** Where does the tadpole or pollywog get its food? **8.** What does the adult frog eat? **9.** Are amphibia (the family to which the frog belongs) harmful? **10.** Are they of any use to man? **11.** Do frogs and toads produce warts on the hands of those touching them?

No. 134. EXPERIMENT ——

Purpose. — To study the development of the house fly in order to determine where it lays its eggs, how many stages it passes through before becoming an adult, and how many days elapse between stages.

Materials.

Method.

Conclusions. — **1.** In what different kinds of materials did you find that the house fly would lay her eggs? **2.** How long were the eggs in hatching? **3.** Name the different stages through which the fly embryo passed, and give the number of days spent in each stage.

Discussion. — **1.** In what way are flies a real menace to human beings? **2.** State four ways in which we may

successfully protect ourselves against the fly. Which is most effective? **3.** Are any flies other than the house fly dangerous to man? If so, in what way? **4.** How may these flies be guarded against?

Diagram. — Draw an effective fly trap, from information furnished by your instructor.

No. 135. EXPERIMENT ——

Purpose. — To study the development of the mosquito, in order to determine the different stages of development.

Materials.

Method.

Conclusions. — Name as many distinct stages as you can in the development of the mosquito from egg to adult. State the number of days from the time you first began to observe the development, until each succeeding stage was begun.

Discussion. — **1.** Why does the "wriggler" or larva come to the surface of the water? **2.** How does the mosquito larva breathe? The mosquito pupa? **3.** The larva molts often during its development. Why? (If you observe the water in which the mosquitoes are developing, you will see many of the cast-off skins.) **4.** During which stages of the mosquito's development is it most easily killed? How? Why? **5.** What constitutes the food of the larva? Of the pupa? Of the male adult? Of the female adult? **6.** Is the culex (house mosquito) harmful? The anopheles? The stegomyia? **7.** How long does a mosquito live? **8.** How does the family of mosquito survive or persist? **9.** How may the anopheles and culex larvæ be distinguished from each other? The anopheles and culex adults? **10.** Name three ways in which mosquitoes may be eliminated.

No. 136. EXPERIMENT ——

Purpose. — To determine what per cent of the vital capacity of one's lungs is used for ordinary breathing.

Materials.

Method.

Conclusions. — **1.** What is the vital capacity of your lungs? **2.** How many cubic centimeters of the tidal air do you take in at an ordinary respiration? **3.** What per cent of your vital capacity, therefore, do you ordinarily use?

No. 137. EXPERIMENT ——

Purpose. — To learn how the diaphragm aids in bringing air into the lungs and expelling it.

Materials.

Method.

Conclusions. — **1.** How does the diaphragm aid in bringing air into the lungs? **2.** How does the diaphragm aid in expelling air from the lungs?

Discussion. — **1.** Why does one "pant" after violent exercise? **2.** By what process is oxygenation of the blood effected? **3.** Explain briefly the action of the diaphragm and chest muscles during inspiration and exhalation. **4.** What is meant by residual air? Supplemental air? Stationary air? Complemental air? **5.** Which is more important, costal (chest) breathing or abdominal breathing? **6.** What harm can result from tight corsets and belts?

No. 138. EXPERIMENT ——

Purpose. — To learn how blood circulates in a living animal.

Materials.

Method.

Conclusions. — **1.** How were you able to determine which were veins, which were arteries, and which were capillaries? **2.** In which of the three was the flow of blood slowest?

No. 139. EXPERIMENT ——

Purpose. — To learn how to "take pulse," in order to determine whether sex and age have anything to do with the rate of the heart beat.

Materials.

Method.

Conclusions. — **1.** Do boys' and girls' hearts beat at about the same rate? **2.** Does the heart of an older person beat at a different rate from that of a younger?

No. 140. EXPERIMENT ——

Purpose. — To determine what different bodies and substances may be found in the human blood.

Materials.

Method.

Conclusions. — **1.** How many different bodies and materials were you able to distinguish in the blood? Describe each. **2.** Are the different kinds of bodies in equal numbers?

Discussion. — **1.** What causes pulse? **2.** Why does the blood flow along through the blood canals? **3.** How

may the fact brought out in the second question in the Conclusion of No. 138 be explained? **4.** What is the function of the capillaries? **5.** What is the function of the phagocytes? **6.** What is the function of the red corpuscles? Where are they made? **7.** What is the function of the plasma? **8.** What is the color of a single red corpuscle? To what is this color due? **9.** To what is the white color of pus due? **10.** Was there any difference in the appearance of the frog or tadpole and human corpuscles? **11.** State two safeguards which nature provides to prevent excessive bleeding in case of a severe cut. **12.** How may excessive bleeding be prevented if an artery is severed?

No. 141. **EXPERIMENT ——**

Purpose. — To determine whether the saliva is acidic, or basic (alkaline), or neutral.

Materials.

Method.

Conclusion. — Is the saliva acidic, basic, or neutral? Why do you think so?

No. 142. **EXPERIMENT ——**

Purpose. — To determine whether the saliva converts starch to grape sugar.

Materials.

Method.

Conclusion. — Does saliva convert starch to grape sugar?

Discussion. — **1.** Give two reasons why food should be thoroughly masticated. **2.** Name and locate the three pairs of salivary glands. **3.** To what substance in the

saliva is due the change in the starch illustrated above? **4.** By what corresponding substance is a similar change of starch effected in corn grains?

No. 143. EXPERIMENT ——

Purpose. — To determine the effect of nicotine upon a living animal such as a minnow or tadpole.

Materials.

Method.

Conclusion. — What is the effect of nicotine upon a living fish or tadpole?

No. 144. EXPERIMENT ——

Purpose. — To determine the effect of alcohol upon white of egg.

Materials.

Method.

Conclusion. — What is the effect of alcohol upon white of egg?

Discussion. — **1.** Since the minnow and the tadpole are typical living animals, what would one infer to be the effect of nicotine upon man? **2.** The Century Dictionary defines a narcotic thus: "A substance which directly induces sleep, allaying sensibility and blunting the senses, and which in large quantities produces narcotism, or complete insensibility." The narcotic influence of tobacco is due to nicotine, a very strong poison which tobacco contains. Authorities tell us that growing boys who smoke become stunted, undersized, and more or less mentally inert. What would be a reason for this? **3.** Explain why insect parasites on plants may be killed by spraying the plants with water in which to-

bacco has been steeped. **4.** Why have smokers "poor wind"? **5.** When a person is chilly, why does an alcoholic beverage *seem* to make one warmer? What really is the effect produced by alcoholic drinks taken at such a time? **6.** How does this experiment illustrate why alcohol has a detrimental effect upon living matter? **7.** How can the effect of this experiment be accounted for? **8.** What is the effect of alcohol upon the stomach, the heart, the blood vessels and the arteries, the liver and kidneys, the lungs, the nerves, etc.? **9.** Are the alcohol users and cigarette smokers discriminated against when it comes to getting employment or getting life insurance, etc.? Why? **10.** Is there any relation between alcohol and heredity?

No. 145. EXPERIMENT ——

Purpose. — To study the "patent medicine question" in order to learn the truth concerning the claims made by patent medicines in general, and concerning the harm which may result from the use of certain patent medicines.

Materials.

Method, Conclusions, and Discussion. — **1.** What danger does one run from taking patent medicines containing acetanilid? **2.** Name ten patent medicines which depend for their results upon the action of acetanilid. **3.** Why can firms afford to distribute free samples of their medicines containing codeine? **4.** What is the danger in dosing babies with patent "soothing sirups"? To what class of drugs is the "soothing" effect of such nostrums due? **5.** Name four patent medicines which contain cocaine as an important ingredient. **6.** Name several patent medicines which contain a large percentage of alcohol. **7.** Why are all headache powders or tablets dangerous? **8.** Why are heart disease, consumption, dropsy, cancer, epilepsy, and paralysis not cur-

able with patent medicines? Why is it dangerous for the sufferer to attempt to cure himself of these diseases with patent nostrums? **9.** Give several reasons why patent medicine " cure alls " are dangerous.

No. 146. EXPERIMENT ——

Purpose. — To learn some simple things which in case of accidents may be done immediately to lessen pain and avert serious consequences.

Materials.

Method and Conclusions.

Discussion. — **1.** What two things is it important to remember whenever some one has been badly injured? **2.** What should always be done for slight cuts and scratches? **3.** Why should every cut, however slight, receive attention? **4.** What may one do to relieve the pain and swelling of a bruise or sprain? Why is this treatment helpful? **5.** What may be done in case of serious burns? **6.** How may a bug be removed from the ear?

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